GENETIC STOCK IDENTIFICATION OF

ALASKA CHINOOK SALMON

Final report of the Alaska Department of Fish and Game pursuant to National Oceanic and

Atmospheric Administration Awards No. NA46FD0356

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Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development
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EXECUTIVE SUMMARY

Identification of the origins of chinook salmon captured as bycatch in fisheries targeting groundfish in the Gulf of Alaska and Bering Sea/Aleutian Islands is a management and conservation concern. Mixed-stock analysis using genetic data has been successfully used to identify stock components of chinook salmon mixtures in Washington and British Columbia and may be an ideal tool for identifying stock of origin of bycaught chinook salmon in Alaskan waters. Though populations of chinook salmon from California to British Columbia have been genetically characterized, data describing Alaskan populations are limited. In this study we collected genetic data from wild-spawning and hatchery populations of chinook salmon from throughout Alaska to better identify populations that may be contributing to bycatch in the Gulf of Alaska and the Bering Sea. We also developed a multiplex screen to assay genetic variation at microsatellite loci, a class of DNA markers. With the allozyme data, we performed simulation studies using maximum likelihood methods to test identifiability of regional stock groupings of chinook salmon in mixtures. Data were included from throughout the North American range of chinook salmon. Eight regions were studied: 1) Western Alaska; 2) Southeast Alaska; 3)British Columbia: non-Fraser River; 4) British Columbia: Fraser River; 5) Puget Sound; 6) Washington Coastal; 7) Columbia River; and 8) California-Oregon. The results of the simulations indicate that major regional groups of chinook salmon can be identified in mixtures with a high degree of accuracy and precision.

INTRODUCTION

Chinook salmon originating in North America and Asia form aggregations composed of numerous populations during their ocean residency in the North Pacific. Identifying the components of these mixtures of chinook salmon caught in international waters, in the U.S. Exclusive Economic Zone, and in the large river systems leading to spawning tributaries, has been the focus of many research studies throughout the Pacific Rim.

During their ocean residency, chinook salmon are caught incidentally by trawl vessels targeting a variety of groundfish, including several flatfish and rockfish species, Atka mackerel, pollock, Pacific cod, and sablefish, in the Bering Sea/Aleutian Islands (BS/AI) and Gulf of Alaska (GOA). Chinook salmon bycatch in these fisheries ranged from 23,079 to 45,905 in the BS/AI, and from 13,973 to 37,592 in the GOA between 1991 and 1995 (David Ackley, Alaska Department of Fish and Game, Juneau, pers. Comm.).

Incidental harvest of chinook salmon in the groundfish fisheries exacerbates chinook salmon allocation issues and may promote chinook conservation problems in Alaska. In addition, considerable attention has been focused recently on the severe depletion of certain chinook salmon stocks in California, Oregon, and Washington (Nehlsen et al. 1991; Waples et al. 1991; Mathews and Waples 1991; Utter et al. 1993), which may also contribute to these fisheries. Because geographically-specific data on stock composition of chinook salmon bycatch in the groundfish fisheries are lacking, the potential impact of these fisheries on chinook salmon stocks cannot be adequately determined. Methods are needed to identify the specific geographic origins

of chinook salmon caught incidentally in the groundfish fisheries in order to address conservation and allocation concerns.

Most chinook salmon caught in the domestic groundfish fisheries probably originate from a large number of river systems in Alaska, British Columbia, and the Pacific Northwest, and to a lesser extent from Asia. However, no recent, definitive data are available to estimate the proportions of chinook salmon from different areas in the bycatch. Myers and Rogers (1988) estimated the stock origins of chinook salmon caught in 1977 to 1982 by foreign and joint venture groundfish vessels operating in the eastern Bering Sea portion of the U. S. Exclusive Economic Zone using scale pattern analyses. Origins of chinook salmon were specified to broad geographic regions such as Western Alaska, Central Alaska, and Southeast Alaska/British Columbia. However, classification accuracies were only above 90% in two-regional models (Meyers and Rogers 1988). Scale pattern data may be most useful in providing qualitative information about the high-seas distribution of chinook salmon (Healey 1991).

Purpose

Mixed-stock analyses (MSA) using proteins detected by allozyme electrophoresis has become an important part of many salmonid management programs (e. g. Milner and Teel 1979; Utter et al. 1987; Shaklee et al. 1990a; Utter et al. 1993; Seeb et al. 1996). The underlying genetic differences among stocks can be used to differentiate groups in mixtures of Pacific salmon (e.g. Milner and Teel 1979; Grant et al. 1980; Seeb et al. 1986; Gall et al. 1989; Seeb et al. 1990,

Seeb et al. 1995a; Seeb et al. 1996), and a statistical framework based on maximum likelihood estimation has been developed to identify individual stocks within mixtures (Milner et al. 1981; Fournier et al. 1984; Millar 1987; Pella and Milner 1987; Smouse et al. 1990; Gomulkiewicz et al. 1990; Masuda et al. 1991; Pella et al. 1996).

The genetic structure of chinook salmon populations has been studied throughout much of the species range in western North America (e.g. Gharrett et al. 1987; Reisenbichler and Phelps 1987; Utter et al. 1989; Beacham et al. 1989; Winans 1989; Bartley and Gall 1990; Bartley et al. 1992; Waples et al. 1993). Utter et al. (1989) identified 9 genetically-defined aggregates from California to British Columbia based upon genetic variation at 25 polymorphic allozyme loci. Gharrett et al. (1987) studied 16 polymorphic allozyme loci in 13 Alaskan river systems ranging from Norton Sound to Southeast Alaska from 37 collections made between 1982 and 1984. They found that chinook salmon from western Alaska were distinct from a rather heterogeneous set of populations from southeastern Alaska. Beacham et al. (1989), studying Canadian populations from the Yukon River, found that riverine populations from the Yukon River drainage showed substantial subdivision, and Wilmot et al. (1992) identified a distinct separation between upper and lower Yukon River stocks.

Data from non-Alaskan populations have been standardized and combined into a "coastwide" baseline managed by National Marine Fisheries Service (NMFS). The database is composed of 196 populations ranging from the Sacramento River in California to the Stikine River in Alaska and British Columbia. Data were collected by NMFS, Washington Department of

Fish and Wildlife (WDFW), and University of California, Davis; a large portion of the data can be found in Utter et al. (1989); Bartley et al. (1992); and Waples et al. (1993). This baseline has been used extensively to estimate the stock contribution to Columbia River, coastal Washington, and Strait of Juan de Fuca fisheries of six major groupings: 1) California-Oregon; 2) Columbia River; 3) Washington Coast; 4) Puget Sound; 5) British Columbia: Fraser River; and 6) British Columbia: non-Fraser River (e.g. Marshall et al. 1991; Miller et al. 1993).

However, a comprehensive database including Alaska populations is necessary before the coastwide baseline can be used in the MSA of fisheries to which Alaskan stocks contribute. Studies by Wood et al. (1987) and Pella and Milner (1987) emphasize the importance of a completely representative baseline. The accuracy of estimates declines and results are biased when stocks are missing or poorly defined. While data from Alaskan studies provide important knowledge about the population structure of Alaskan chinook salmon, many major populations are not genetically well-characterized. For example, most of the western Alaska samples used by Gharrett et al. (1987) were collected from population mixtures at the mouths of major river systems and may be of limited value for some mixed-stock questions. Representative collections of spawning populations from the Unalakleet River, the Kuskokwim River, Bristol Bay, the Alaska Peninsula, Kodiak Island, Cook Inlet, Kenai Peninsula, and the Copper River are necessary. Furthermore, hatcheries in Southeast Alaska now release more than seven million chinook salmon juveniles annually, so they must also be represented in the baseline.

We collected genetic data from 18 wild and 4 hatchery populations of chinook salmon in Year 1 of this project. Our Year 1 analysis indicated that four genetic groups of chinook salmon exist within the state: Southeast Alaska, Chilkat River, Southcentral Alaska, and Northwest Alaska (Seeb et al. 1995b). Our objectives in Year 2 were 1) to extend the existing allozyme data for Alaska wild and hatchery chinook salmon to more accurately characterize individual stocks in bycatch mixtures, 2) to evaluate the use of these data to identify stock components of the chinook salmon bycatch from trawl fisheries in the BS/AI and GOA areas, and 3) to contribute to the development of DNA-based markers (Appendix 1). In this report, we discuss genetic relationships among chinook salmon populations in Alaska analyzed in both Year 1 and Year 2. We also report on preliminary studies evaluating the ability of these data and data from the coastwide baseline to identify regional stock groupings in mixtures.

APPROACH

Sample Collection and Laboratory Analysis

Approximately 4000 individuals comprising 51 samples from 39 populations were collected for genetic analysis of Alaskan chinook salmon (Table 1, Figure 1). Adult chinook salmon were sampled from spawning grounds throughout Alaska and the Yukon Territory. If adults could not be obtained, juveniles were collected from their freshwater-rearing habitat. In Southeast Alaska, we sampled hatchery stocks and the wild populations used as their broodsources to complement an extensive wild-stock database nearing completion by NMFS-Auke Bay Laboratory. We also sampled chinook salmon from the Chilkat River in Southeast Alaska. Our sampling goal was 100 adults or 150 juveniles per population (Allendorf and Phelps 1981). Individual tissues (muscle, liver, eye, and heart) were dissected from the fish, placed in 2.0 ml cryotubes, and quickly frozen in liquid nitrogen or on dry ice. Samples were stored at -80° C until subsampled for allozyme analysis.

Variation at 69 enzyme-encoding loci was assayed from protein extracts of muscle, liver, eye and heart tissues using the general protocols outlined in Harris and Hopkinson (1976), May et al. (1979), and Aebersold et al. (1987) (Table 2). We used the enzyme nomenclature adopted by the American Fisheries Society (Shaklee et al. 1990b).

Statistical Analysis

Individual genotypic data were summarized into allelic frequencies for all 69 loci except *GPI-B2**, *GPIr**, and *sMEP-2**. Heterozyote phenotypes at *GPIr** and *sMEP-2** cannot be

consistently scored (David Teel, NMFS, Manchester, pers. comm.); therefore we calculated dominant and recessive phenotypic frequencies. Similarly, the **100/*60* phenotype cannot be distinguished from the **100/*100* phenotype at *GPI-B2**. Dominant and recessive phenotypic frequencies were calculated for *GPI-B2*100* and **60* (**24* pooled with **100*) and reported as *GPI-B2**, and allelic frequencies were calculated for **100* and **24* (**60* pooled with **100*) and reported as *GPI-B2a** (David Teel, NMFS, Manchester, pers. comm.).

We used 34 polymorphic loci (*sAAT-1,2**, *sAAT-3**, *sAAT-4**, *mAAT-1**, *mAAT-2**, *ADA-1**, *sAH**, *ALAT**, *GAPDH-2**, *GPI-A**, *GPI-B2**, *GPI-B2a**, *GPI-r**, *HAGH**, *sIDHP-1**, *sIDHP-2**, *LDH-B2**, *sMDH-A1,2**, *sMDH-B1,2**, *sMEP-1**, *sMEP-2**, *MPI**, *PEPA**, *PEPB-1**, *PEPD-2**, *PGK-2**, *PGM-2**, *IDDH-1**, *sSOD-1**, *TPI-3**, and *TPI-4**) scored in all populations to assess genetic variation. We tested for departure from Hardy-Weinberg equilibrium (α=0.05, adjusted for multiple tests using a sequential Bonferroni correction [Rice 1989]) and calculated observed and expected heterozygosity for all loci except *GPI-B2**, *GPIr**, and *sMEP-2**. Analyses were performed using S-PLUS software package (Version 3.3, MathSoft Inc., Seattle, WA).

Genetic Variation Within and Among Wild Populations

We used multidimensional scaling (MDS; Krzanowski and Marriott 1994) of Cavalli-Sforza and Edwards chord distances (Cavalli-Sforza and Edwards 1964) to describe genetic relationships among wild-stock populations. This analysis groups populations in multidimensional space so that resulting interpopulation distances closely match the observed distances.

Wild populations were sorted into a hierarchy based on the results of the MDS analysis and geographic proximity. Geographic and temporal heterogeneity among wild-stock populations were evaluated with a hierarchical likelihood ratio analysis (G-statistic [Sokal and Rolf 1995], modified from Weir 1990). All comparisons were planned and independent, and the significance of the results was determined according to Milliken and Johnson (1984), α=0.05. A gene diversity analysis (Nei 1973) was used to partition genetic variance into within-population, among-populations-within-drainage, among-drainages-within-region, and among-regions components. Isolocus (*sAAT-1,2*; sMDH-A1,2**; and *sMDH-B1,2**) and phenotypic (*GPI-B2*; GPIr**; and *sMEP-2**) frequencies were not used in gene diversity computations.

For the preceding analyses, data from all wild populations were used except the Farragut River. Coded-wire tag data has shown that chinook salmon from several hatcheries stray into this river (Heard 1996), affecting our ability to accurately estimate allele frequencies for the Farragut River.

Relationships Within and Among Hatcheries

We used likelihood ratios to test for allele frequency homogeneity within and among hatchery populations sampled in Southeast Alaska. Specifically, we tested for temporal stability of allele frequencies of a broodstock within hatcheries; allele frequency homogeneity among hatcheries using the same broodstock; and homogeneity of allele frequencies between a hatchery stock and its wildstock progenitor. Significance was determined by adjusting for multiple tests, α=0.05 (Rice 1989).

To further contrast temporal stability within hatchery stocks and wildstocks, we calculated the percent of loci with significant allele frequency differences between years in each population sampled more than once (Waples 1991). By chance alone, 5% of the tests for each population are expected to be significant. The degree of precision around the estimated percent of loci with significant allele frequency differences was calculated according to Cochran (1977) given the number of possible comparisons within each population, α=0.05.

Simulation Studies

We evaluated the data collected in this study and the coastwide baseline for chinook salmon for their ability to identify stock components in mixtures by using simulation studies. The following loci were used in the simulation analysis: *sAAT-1,2*; sAAT-3*; mAAT-1*; ADA-1*; sAH*; GPI-A*; GPIr*; HAGH*; mIDHP-2*; sIDHP-1,2*; LDH-B2*; LDH-C*; sMDH-A1,2*; sMDH-B1,2*; sMEP-1*; sMEP-2*; MPI*; PEPA*; PEPB-1*; PEPD-2*; PGK-2*; sSOD-1**; and *TPI-4**. A locus was selected if it was polymorphic in at least one population and if it was scored for all Alaskan and trans-boundary Alaskan/British Columbian populations. Populations were included in the analysis if they had data for all loci and if they had a minimum sample size of 40 individuals per population group (Wood et al. 1987). We used 134 population groups from the coastwide baseline; each geographic subregion in the coastwide database was represented by at least one population (Table 3). We used all Alaskan data except Farragut River 1993 and 1994, Takotna River 1992, and King Salmon River 1992.

Alaskan data were modified for consistency with the coastwide baseline. While *sIDHP-1** and *sIDHP-2** have been scored as two loci in recent years (Shaklee and Phelps 1992), they were scored as an isolocus pair for many of the populations in the coastwide baseline. Therefore, *sIDHP-1** and *sIDHP-2** for Alaskan populations were recalculated as an isolocus. In addition, the following alleles in Alaskan populations were pooled to follow the format of the coastwide baseline: *sIDHP-1,2*94* with *sIDHP-1,2*100*; *sIDHP-1,2*83* with *sIDHP-1,2*74; sIDHP-1,2*129* with *sIDHP-1,2*127*; *PEPA*86* with *PEPA*90*; and *PEPB-1*-350* with *PEPB-1*100*. Multiple-year collections from the same population were pooled, even if significant differences were detected using likelihood ratio tests. Waples (1990) recommended pooling multiple year samples to counteract uncertainty in allele frequency estimates due to drift.

Collections used in the analysis were organized into eight groups by region: 1) California-Oregon; 2) Columbia River; 3) Washington Coast; 4) Puget Sound; 5) British Columbia: Fraser River; 6) British Columbia: non-Fraser River; 7) Southeast Alaska; and 8) Western Alaska. These groups included the six major geographic groups used by Marshall et al. (1991) and two Alaskan groups identified from the results of the multidimensional scaling analysis. Iskut River and Little Tahltan River, Canadian tributaries to the Stikine River in Southeast Alaska, were grouped with Southeast Alaska because of geographic proximity.

The baseline constructed in this study was evaluated for its ability to identify these regional groups in mixtures using simulations. In a simulation, new baseline and mixture genotypes were randomly generated from the baseline using Hardy-Weinberg expectations.

Average mixture estimates were derived from 100 simulations for each region, where each region comprised 100% of the mixture (N=400). When more than one stock was included in the reporting region, each stock contributed equally to the total mixture. The standard error of the mean was estimated by a parametric bootstrap (Efron and Tibshirani 1986). The region was considered identifiable if at least 90% of the mixture on average allocated to the correct region. Simulations were performed using the Statistical Package for Analyzing Mixtures (SPAM) developed by ADF&G using the GIRLS (Masuda et al. 1991) and CONJA-S (Pella et al. 1996) algorithms.

FINDINGS

Polymorphisms were observed in 44 of the 69 loci assayed for genetic variation in Alaskan chinook salmon. Allele frequency estimates for 36 polymorphic loci are presented in Table 4; we did not estimate allele frequencies for *ADA-2**; *mAH-3**; *mAH-4**; *CK-C2**; *GR**; *LDH-B1**; *mMDH-1**; and *mMEP-2** because of insufficient resolution.

Tests for conformation to Hardy-Weinberg expectations were conducted on all loci used in the statistical analysis except *GPI-B2**, *GPIr**, and *sMEP-2**. None of the 51 populations tested were out of Hardy-Weinberg equilibrium. Observed and expected heterozygosity ranged from 0.0343 and 0.0354 in North Klondike River 1993 to 0.1027 and 0.1067 in Chickamin River 1995 (Table 4).

Relationships Within and Among Wild Populations

Multidimensional scaling indicated that at least two distinct lineages of chinook salmon are present in Alaska, one composed of populations from Southeast Alaska and one composed of populations west and north of the Copper River (Figure 2). This analysis also indicated that populations within the Southeast region are more divergent than those in the Western region. Three distinct groups are apparent within Southeast Alaska, the Chilkat River, King Salmon River, and the remaining Southeast populations. Western Alaska populations grouped tightly. We performed another multidimensional scaling analysis on Western populations to determine if the large genetic differences between Southeast and Western Alaska masked substructuring of populations in Western Alaska (Figure 3). This analysis showed a comparatively close

relationship among populations from the Susitna River drainage and from the Naknek River in Bristol Bay to the Unalakleet River, but that populations in the Yukon River in Canada and from the Alaska Peninsula, Kodiak Island, Kenai Peninsula, and the Gulkana River are divergent.

The heterogeneity analysis detected significant allele frequency differences between populations in Southeast and Western Alaska (likelihood=2620.20, df=50, P<0.0000; Table 5). This is primarily due to the higher frequency of *sMEP-1*92* and *sIDHP-1*94* and the relative absence of *TPI-4*104* in Southeast Alaska populations. Significant heterogeneity within Southeast Alaska was detected among the Chilkat River, King Salmon River, Unuk River, and Chickamin River drainages (likelihood=815.00, df=150, P<0.0000; Table 5). No heterogeneity was detected among tributaries of the Chilkat River (likelihood=90.05, df=150, P=1.0000; Table 5) nor among multiple year collections within Big Boulder Creek (likelihood=21.88, df=50, P=0.9998; Table 5).

Significant heterogeneity was detected in Western Alaska (likelihood=2705.00, df=450, P<0.0000; Table 5). Significant allele frequency differences occurred among populations within the Copper River (likelihood=80.33, df=50, P=0.0042; Table 5); Cook Inlet (likelihood=247.20, df=50, P<0.0000; Table 5); the Alaska Peninsula (likelihood=93.33, df=50, P=0.0002; Table 5); and the Yukon River (likelihood=582.00, df=50, P<0.0000; Table 5). However, no allele frequency differences were found among populations within Bristol Bay and the Kuskokwim River. No temporal variability was observed in any multiple year collection.

A gene diversity analysis was used to partition genetic variation into within-population, among-populations-within-drainages, among-drainages-within-regions, and between-region components. Most of the genetic variability in Alaskan chinook salmon is due to within population variation (93%), followed by variation among drainages within regions (4.3%), among regions (1.9%), and within drainages (1.2%; Table 6).

Relationships Within and Among Hatcheries

We used likelihood ratios to test three hypotheses concerning allele frequencies in Southeast Alaska hatcheries: 1) allele frequencies within hatchery broodstocks are temporally stable; 2) allele frequencies among hatcheries using the same broodstocks are homogeneous; and 3) allele frequencies of hatchery broodstocks are similar to their wildstock progenitors. We found that allele frequencies were not temporally stable for Chickamin River-Whitman Lake Hatchery (WHL), Unuk River-Deer Mountain Hatchery (DMT), or for Andrew Creek-Hidden Falls Hatchery (HFL) (Table 7a). We detected allele frequency heterogeneity between hatcheries using identical broodstocks: Whitman Lake and Little Port Walter hatcheries (Chickamin River broodstock), Deer Mountain and Little Port Walter Hatcheries (Unuk River broodstock), and Hidden Falls and Crystal Lake Hatchery (Andrew Creek broodstock) (Table 7b). Finally, we detected significant heterogeneity between hatchery broodstocks and their wildstock progenitors for Chickamin River-WHL, Chickamin River-Little Port Walter Hatchery (LPW), Unuk River-DMT, and Unuk River-LPW (Table 7c). No heterogeneity was observed between King Salmon River-LPW and King Salmon River (Table 7c).

Temporal variation was greater in each of the hatchery stocks examined than in wild populations as can be seen by comparing the percent of loci with significant allele frequency differences in the collections of wild populations (seven populations; 120 tests; 6% ± 4% of tests were significant), Andrew Creek-HFL (24% tests; 25 ± 9% of tests were significant), Unuk River-DMT (24% tests; 21 ± 9% of tests were significant), and Chickamin River-WHL (22% tests; 27 ± 10% of tests were significant) (Figure 4). By chance, 5% of the tests are expected to be significant, but the percent of significant tests within the hatcheries tested exceeded this expectation.

Simulation Studies

Eight reporting regions were evaluated in the simulation study. Each region in the performed extremely well, with mean allocations above 90% for Western Alaska; Southeast Alaska; British Columbia; non-Fraser River; British Columbia: Fraser River; Puget Sound; Columbia River; and California-Oregon (Table 8). Washington Coastal had a mean allocation of 84%, with a 5.6% misallocation to Washington-Oregon and a 4.6% misallocation to Puget Sound.

EVALUATION

The success of MSA depends partly on the accurate characterization of potentially contributing stocks and the magnitude of allele frequency differences among them (Pella and Milner 1987). Data collected in this study provide the most comprehensive genetic database for chinook populations in Alaska. Gharrett et al. (1987) also furnished a statewide analysis of chinook salmon. However, their data, while giving an understanding of genetic relationships among populations, have limited use in MSA applications. Many of the baseline populations examined were from a mixed origin, and the analysis was based on a comparatively small number of loci. Other studies, though comprehensive in the number of loci examined, studied genetic relationships among chinook salmon in a single geographic area (Yukon River: Beacham et al. 1989; Wilmot et al. 1992; Southeast Alaska: NMFS-Auke Bay, unpublished). By sampling spawning populations in underrepresented areas in Western Alaska, Southcentral Alaska, and hatcheries in Southeast Alaska, we have compiled a baseline suitable for MSA and complementary to previous studies.

Analysis of genetic relationships among populations examined in this study indicated two major genetic lineages of chinook salmon are present in Alaska, one composed of Southeast Alaska populations and one composed of populations from the Copper River west and north. Several loci exhibited large frequency differences between the two lineages. For example, *TPI-3*96* and *sIDHP-1*94* are present in most Southeast Alaska populations, yet are entirely absent from Western Alaska. Conversely, *TPI-4*104* is present in all Western Alaska populations, but

is only found in the Chilkat River in Southeast Alaska. Further study of spawning populations located between the Copper River and the Chilkat River, for example Alsek River, Situk River, and Yakataga River, is necessary to locate the demarcation between the two lineages and to accurately estimate their origin and phylogenetic relationships within and between the lineages.

Within the Southeast Alaska lineage, King Salmon River was an extremely divergent population. This population contained unique allele frequencies at *sAAT-4** and *GPI-B2** (Table 4). Though our sample size for this population was very small (N=14), these aberrant frequencies probably were not due to sampling error; allele frequencies for this sample were statistically indistinguishable from King Salmon River-LPW. The King Salmon River fish sampled at Little Port Walter Hatchery were first generation progeny of approximately 70 King Salmon River wild fish used to found the stock in 1988 and 1989 (McGee et al. 1993). Chinook salmon in the King Salmon River are biologically unique as well. It is one of the few remaining island populations of chinook salmon in Southeast Alaska and has some unique features, including intertidal spawning and an earlier runtiming than other Southeast populations (Halupka et al. 1996).

Gharrett et al. (1987) hypothesized that Southeast Alaska chinook salmon streams may have been partially colonized via headwater transfer events from the Canadian portion of the Yukon River. Though our multidimensional scaling analysis did not group Yukon River populations with any Southeast Alaska population, our data provide some circumstantial evidence that the Chilkat River may have been influenced by the upper Yukon River. A *TPI-4** allele, present in all Western Alaska and Canadian Yukon populations, is found at a low frequency in the

Chilkat River and not in other Southeast Alaska collections analyzed in this study. The presence of this allele could be due to historic gene exchange among populations in the two river systems. Further study of chinook salmon populations between the Chilkat River and the Copper River would allow the testing of this hypothesis; if *TPI-4*104* is present in these stocks, the presence of this allele in the Chilkat River may only be due to coastal straying between the two lineages.

Geographic patterns of variation among southcentral and northwestern Alaskan stocks are difficult to detect in the multidimensional scaling analysis. In general, Alaskan populations from the Naknek River north to the Unalakleet River are tightly grouped. Unexpectedly, the four populations from the Susitna River (Prairie Creek, Moose Creek-Deshka River, Deception Creek, and Talachulitna River) were most closely associated with populations from Northwest Alaska and not with other Southcentral populations. Seeb et al. (1995b) also observed a close relationship between a chum salmon population in the Susitna drainage with Northwestern Alaska chum salmon populations. They hypothesized that chum salmon populations in this region were founded after the last glaciation by stream transfer from interior Alaska instead of from seawater migration via Cook Inlet. This pattern may be repeated in chinook salmon as well.

Populations from Kodiak Island, the Alaska Peninsula, and the Canadian Yukon River were extremely divergent, not forming any regional pattern. This may be due to several factors including 1) inadequate geographic coverage of these areas may not allow demonstration of genetic relationships, and 2) genetic drift within these populations because of their isolation. For instance, only 10 river systems support chinook salmon spawning on the North Alaska Peninsula

(Murphy 1995), and no chinook salmon populations exist on the South Alaska Peninsula west of Kupreanof Point (McCullough 1995), limiting the opportunity for gene flow.

The extent of the temporal variation in chinook salmon hatchery stocks analyzed in this study is disturbing but not unexpected. Waples and Teel (1990) previously described allele frequency fluctuations in hatchery stocks of salmonids in the Pacific Northwest, attributing allele frequency changes to small numbers of effective breeders. In this study, we found a similar pattern. Within each hatchery studied over multiple years, allele frequencies were not temporally stable, and significant tests of allele frequency changes occurred more frequently in hatcheries than within wild stocks. Such fluctuations may have a direct impact on the effectiveness of MSA, which requires prior characterization of the component stocks. If successive broodyears of a hatchery stock are significantly different, then the baseline must reflect all broodyears expected to contribute to the harvest (Waples 1990).

Further, because significant allele frequency differences were found among hatcheries using the same broodstock it cannot be assumed that allele frequencies in hatcheries using identical broodstocks will be identical. In addition, sampling wildstocks used as broodsources may not adequately represent allele frequencies of hatchery stocks. All hatcheries potentially contributing to commercial catches or in bycatch will need to be sampled over multiple years. This is especially critical because hatchery stocks have been shown to contribute up to 30% of Southeast Alaska fisheries (McGee et al. 1990).

The magnitude of allele frequency differences among the eight reporting regions tested in this study (Western Alaska; Southeast Alaska; British Columbia: non-Fraser River; British Columbia: Fraser River; Washington Coastal; Puget Sound; Columbia River; and California-Oregon) are sufficiently large to permit their accurate identification. All reporting regions with the exception of Washington Coastal had mean allocations exceeding 90%. With the addition of Alaskan data obtained in this and other studies, it will soon be possible to use MSA to identify stock of origin of bycatch in the Bering Sea and Gulf of Alaska.

CONCLUSION AND FUTURE DIRECTION

Data collected in this study demonstrated significant genetic structuring among populations of chinook salmon in Alaska. Further, the simulations using these data and data from the coastwide baseline for chinook salmon indicated that MSA using allozyme data will be a powerful tool to accurately identify the contribution of Alaskan populations in bycatch or other highseas samples.

Chinook salmon bycatch can have negative affects on a broad range of users of chinook salmon and groundfish resources. These incidental catches may have detrimental effects on directed commercial, sport, and subsistence chinook salmon fisheries. In addition, management actions which may be taken to limit the incidental catch of chinook salmon may affect the groundfish industry. Similarly, many sectors of the fishing industry will benefit from successful efforts to manage chinook bycatch.

We are interested in continuing to refine and evaluate the allozyme baseline for chinook salmon. We will test the effects of adding and deleting loci in the baseline performance and the use of genetically-based rather than geographically-based reporting regions. We plan to determine if finer regional reporting groups for Alaska are possible, but first recommend the addition of data from the Yukon River (Wilmot et al. 1992), Southeast Alaska wild stocks (NMFS-Auke Bay, unpublished), and Alaska/British Columbia transboundary rivers (NMFS-Auke Bay, unpublished) and further analysis of populations from the Kenai Peninsula and Copper River. The addition of Asian data to the baseline is essential in order to address Bering Sea

fishery bycatch. Asian chinook salmon are present in the Bering Sea and in the Western North Pacific to approximately 175°W and are second in abundance only to Western Alaska stocks (Healey 1991). Finally, we plan to continue the development of DNA markers (see Appendix 1) in cooperation with other laboratories to determine the utility of these markers for population assessment and identification in comparison to the allozyme baseline.

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Table 1. Collection location, life history stage of samples (A=adult, J=juvenile), sample size, and collection year of chinook salmon populations analyzed to date. Reference numbers are given in parentheses and refer to map locations in Figure 1.

Location	Life Stage	N	Year
Southeast			
Chickamin River			
Little Port Walter Hatchery (1)	A	100	1993
Whitman Lake Hatchery (2)	A	100	1992
Whitman Lake Hatchery (2)	A	55	1994
Chickamin River (3)	J	150	1995
Unuk River			
Deer Mountain Hatchery (4)	A	100	1992
Deer Mountain Hatchery (4)	A	53	1994
Little Port Walter Hatchery (1)	A	100	1993
Unuk River (5)	J	150	1994
Andrew Creek			
Crystal Lake Hatchery (6)	A	100	1992
Hidden Falls Hatchery (7)	A	60	1994
Hidden Falls Hatchery (7)	J	150	1994
Farragut River (8)	J	38	1993
Farragut River (8)	A	55	1993
Farragut River (8)	J	85	1994
King Salmon River			
King Salmon River (9)	A	14	1992
Little Port Walter Hatchery (1)	A	100	1993
Chilkat River			
Big Boulder Creek (10)	A	21	1992
Big Boulder Creek (10)	A	25	1993
Kelsall River (11)	A	45	1992
Tahini River (12)	A	69	1992
Central			
Copper River			
Klutina River (13)	A	23	1991
Gulkana River (14)	J	94	1994
Kasilof River	J		
Crooked Creek Hatchery (15)	A	87	1992
Kenai River (16)	J	150	1993
Susitna River			
Talachulitna Creek (Yentna River) (18)	A	53	1995
Deception Creek (17)	A	103	1991
Moose Creek (Deshka River) (19)	A	51	1995

Table 1. Continued.

Location	Life Stage	N	Year
Prairie Creek (Talkeetna River) (20)	A	52	1995
Alaska Peninsula and Kodiak Island			
Kodiak Island			
Karluk River (21)	A	67	1993
Ayakulik River (22)	A	100	1993
South Peninsula			
Chignik Lagoon (23)	A	47	1995
North Peninsula			
Nelson Lagoon (24)	J	150	1995
Bristol Bay			
Naknek River (25)	A	100	1995
Nushagak River			
Stuyahok River (26)	A	36	1993
Stuyahok River (26)	A	51	1994
Upper Nushagak River (27)	A	53	1993
Upper Nushagak River (27)	A	100	1994
Togiak River (28)	A	63	1993
Togiak River (28)	A	100	1994
Northwest			
Goodnews River (29)	A	40	1993
Kanektok River (30)	A	31	1992
Kanektok River (30)	A	47	1993
Kuskokwim River			
Tuluksak River (31)	A	50	1993
Kogrukluk River (32)	A	50	1992
Kogrukluk River (32)	A	50	1993
Stony River (33)	A	100	1994
Takotna River (34)	A	13	1992
Yukon River			
North Klondike River (35)	J	150	1993
Takhini River			
Stoney Creek (36)	J	185	1992
Unalakleet River (37)	A	24	1992
Unalakleet River (37)	A	71	1993
Total		3861	

Table 2. Buffers and tissues used to resolve loci in chinook salmon. Enzyme nomenclature follows Shaklee et al. (1990b), and locus abbreviations are given.

Enzyme or Protein	Enzyme Number	Locus	Tissue	Buffer[1]
Aspartate aminotransferase	2.6.1.1	*sAAT-1,2**	H	ACEN6.8,TC4
		*sAAT-3**	E	TG
		*sAAT-4**	L	ACE6.8
		*mAAT-1**	H,M	ACE6.8,TC4
		*mAAT-2**	H,M	ACE6.8,TC4
		*mAAT-3**	H,M	ACE6.8,TC4
Adenosine deaminase	3.5.4.4	*ADA-1**	H,M	TG, TC4
		*ADA-2**	H,M	TG, TC4
Aconitate hydratase	4.2.1.3	*mAH-3**	H,E	ACE6.8
		*mAH-4**	H,E	ACE6.8
		*sAH**	L	ACEN6.8
Alanine aminotransferase	2.6.1.2	*ALAT**	M	TG
Creatine kinase	2.7.3.2	*CK-B**	E	TG
		*CK-C1**	E	TG
		*CK-C2**	E	TG
Fumarate hydratase	4.2.1.2	*FH**	M	ACE6.8
Glyceraldehyde-3-phosphate dehydrogenase	1.2.1.12	*GAPDH-1**	H,M	ACEN6.8
		*GAPDH-2**	H	ACEN6.8
		*GAPDH-4**	E	ACE6.8
		*GAPDH-5**	E	ACE6.8
Glycerol-3-phosphate dehydrogenase	1.1.1.8	*G3PDH-1**	H	ACEN6.8
		*G3PDH-2**	H	ACEN6.8
		*G3PDH-3**	H	ACEN6.8
		*G3PDH-4**	H	ACEN6.8
Glucose-6-phosphate isomerase	5.3.19	*GPI-B1**	M	TG
		*GPI-B2**	M	TG
		GPI-A	M	TG
		*GPIr**	M	TG
Glutathione reductase	1.6.4.2	*GR**	M,L,H,E	TC4,TBCL
Hydroxyacylglutathione hydrolase	3.1.2.6	*HAGH**	H	TG
L-Iditol dydrogenase	1.1.1.14	*IDDH-1**	L	TBCL
		*IDDH-2**	L	TBCL
Isocitrate dehydrogenase (NADP+)	1.1.1.42	*mIDHP-1**	M,H	ACE6.8, TC4
		*mIDHP-2**	M,H	ACE6.8,TC4
		*sIDHP-1**	M,H,L,E	TC4, ACE6.8
		*sIDHP-2**	M,H,L,E	TC4, ACE6.8
L-Lactate dehydrogenase	1.1.1.27	*LDH-A1**	M	TG
		*LDH-A2**	M	TG
		*LDH-B1**	E	TG
		*LDH-B2**	E, L	TG
		*LDH-C**	E	TG, ACE6.8

Table 2. Continued.

Enzyme or Protein	Enzyme Number	Locus	Tissue	Buffer[1]
Malate dehydrogenase	1.1.1.37	*sMDH-A1,2**	H,M	ACEN6.8, ACE6.8
		*sMDH-B1,2**	H,M	ACEN6.8, ACE6.8
		*mMDH-1**	H,M	ACEN6.8, ACE6.8
		*mMDH-2**	H,M	ACEN6.8, ACE6.8
		*mMDH-3**	H,M	ACEN6.8, ACE6.8
Malic enzyme (NADP+)	1.1.1.40	*sMEP-1**	H,L	TC4, ACE6.8
		*sMEP-2**	H,L	TC4, ACE6.8
		*mMEP-1**	H	TC4
Mannose-6-phosphate isomerase	5.3.1.8	*MPI**	H	TG
Dipeptidase	3.4.-.-	*PEPA**	E	TG
Tripeptide aminopeptidase	3.4.-.-	*PEPB-1**	H,M	TG, TC4
Peptidase-C	3.4.-.-	*PEPC**	E	TG
Proline dipeptidase	3.4.13.9	*PEPD**	M,H	TC4, ACEN6.8
Peptidase-LT	3.4.-.-	*PEP-LT**	H,M	TG
Phosphogluconate dehydrogenase	1.1.1.44	*PGDH**	L, H	ACE6.8
Phosphoglucomutase	5.4.2.2	*PGM-1**	H,M	TG
		*PGM-2**	H.M	TG
Phosphoglycerate kinase	2.7.2.3	*PGK-1**	M	ACE6.8
		*PGK-2**	M,E	ACE6.8
Superoxide dismutase	1.15.1.1	*mSOD-1**	H	TG, TC4
		*sSOD-1**	H	TG, TC4
Triose-phosphate isomerase	5.3.1.1	*TPI-1**	E,H	TG
		*TPI-2**	E,H	TG
		*TPI-3**	E,H	TG
		*TPI-4**	E,H	TG

[1]ACE6.8 = amine-citric acid-EDTA buffer, pH 6.8; ACEN6.8 = amine-citric acid-EDTA-NAD buffer, pH 6.8 (Clayton and Tretiak 1972); TBCL = Tris-citric acid gel buffer, lithium hydroxide-boric acid electrode buffer,pH 8.5 (Ridgway et al. 1970); TC4 = Tris-citric acid buffer, pH 5.95 (Schaal and Anderson 1974); TG = Tris-glycine buffer, pH 8.5 (Holmes and Masters 1970).

Table 3. Populations included in the coastwide genetic baseline for chinook salmon. Population groups used in the simulation study are marked with an asterisk.

Region	Subregion	Population Group	Sampling Location	Runtime
1) California-Oregon	Sacramento River Spring (Fall and Winter)	Mokelumne-Nimbus*	Mokelumne 1984	Fall
			Nimbus 1981	Fall
			Nimbus 1984	Fall
			Nimbus 1988	Fall
		Feather*	Feather 1981	Fall
			Feather 1984	Fall
			Feather 1988	Fall
		Coleman Battle*	Coleman Battle Creek 1981	Fall
			Coleman Battle Creek 1987	Fall
		Feather*	Feather 1981	Spring
			Feather 1984	Spring
			Feather 1988	Spring
		Merced*	Merced 1988	Fall
		Upper Sacramento*	Upper Sacramento 1987	Winter
	California Coastal (Fall)	Mattole*	Mattole 1984	Fall
			Mattole 1987	Fall
		Mad*	Mad 1984	Fall
			Mad 1987	Fall
		Redwood Creek*	Redwood Creek -Lagoon 1987	Fall
			Redwood Creek Orick 1987	Fall
		Van Duzen River*	Van Duzen River 1987	Fall
		Salmon Creek*	Salmon Creek 1987	Fall
		Redwood Creek	Redwood Creek 1987	Fall
		Benbow*	Benbow 1987	Fall
		Hollow Tree Creek*	Hollow Tree Creek 1987	Fall
		Mid Fork Eel*	Mid Fork Eel 1987	Fall
		North Fork Mad*	North Fork Mad 1987	Fall
	Klamath Spring (Fall)	Trinity	Trinity 1982	Spring
			Trinity 1984	Spring
		Iron Gate*	Iron Gate 1984	Fall
			Iron Gate 1987	Fall
			Iron Gate 1981	Fall
		Trinity*	Trinity 1981	Fall
			Trinity 1984	Fall
			Trinity 1987	Fall
		Salmon- Scott*	Salmon 1987	Fall
			Scott 1984	Fall
		Shasta-Bogus*	Shasta 1984	Fall
			Shasta 1987	Fall
			Bogus Creek 1987	Fall
		Omagar Creek*	Omagar Creek 1988	Fall
		South Fork Trinity*	South Fork Trinity 1987	Fall
	Smith (Fall)	Rowdy Creek*	Rowdy Creek 1984	Fall
			Rowdy Creek 1987	Fall
		Mid Fork Smith*	Mid Fork Smith 1987	Fall
	South Oregon Coastal Spring (Fall)	Cole Rivers	Cole Rivers 1981	Spring
			Cole Rivers 1985	Spring
		Winchuk-Chetco*	Winchuck 1984	Fall
			Chetco 1981	Fall
			Chetco 1984	Fall
			Chetco 1988	Fall
		Cole Rivers	Cole Rivers 1984	Fall
			Cole Rivers 1985	Fall
		Applegate*	Applegate 1984	Fall
			Applegate 1988	Fall
		Pistol	Pistol 1984	Fall
		Lobster Creek	Lobster Creek 1982	Fall
		Rogue At Gold Hill*	Rogue At Gold Hill 1988	Fall
	North Oregon Coastal Spring (Fall)	Rock Creek	Rock Creek 1981	Spring
			Rock Creek 1985	Spring
		Trask	Trask 1981	Spring
			Trask 1985	Spring
		Elk*	Elk 1981	Fall

Table 3. Continued.

Region	Subregion	Population Group	Sampling Location	Runtime
			Elk 1985	Fall
			Elk 1988	Fall
		Sixes Estuary	Sixes Estuary 1981	Fall
			Sixes Estuary 1983	Fall
		Coquille Estuary	Coquille Estuary 1981	Fall
			Coquille Estuary 1983	Fall
		Siuslaw Bay	Siuslaw Bay 1981	Fall
			Siuslaw Bay 1983	Fall
		Alsea	Alsea Bay 1981	Fall
			Alsea Bay 1983	Fall
		Fall Creek*	Fall Creek 1981	Fall
			Fall Creek 1985	Fall
			Fall Creek 1988	Fall
		Siletz Estuary-Nestucca Bay	Siletz Estuary 1981	Fall
			Siletz Estuary 1983	Fall
			Nestucca Bay 1981	Fall
			Nestucca Bay 1983	Fall
		Trask*	Trask 1981	Fall
			Trask 1985	Fall
			Trask 1987	Fall
		Tillamook Bay	Tillamook Bay 1981	Fall
			Tillamook Bay 1983	Fall
		Nehalem Estuary	Nehalem Estuary 1981	Fall
			Nehalem Estuary 1982	Fall
		South Fork Coquille*	South Fork Coquille 1988	Fall
		Millicoma*	Millicoma 1988	Fall
		Morgan Creek*	Morgan Creek 1988	Fall
		Salmon	Salmon 1985	Fall
2) Columbia River	Lower Columbia River (Spring)	Mckenzie - Dexter*	Mckenzie 1982	Spring
			Dexter1987	Spring
			Mckenzie 1988	Spring
		Kalama*	Kalama 1982	Spring
			Kalama 1990	Spring
		Cowlitz*	Cowlitz 1982	Spring
			Cowlitz 1987	Spring
		Lewis River*	Lewis River 1988	Spring
		Clackamas*	Clackamas 1988	Spring
		Marion Forks*	Marion Forks 1990	Spring
	Lower Columbia River and Bonneville Pool (Fall)	Washougal	Washougal 1982	Fall
			Washougal 1985	Fall
		Cowlitz*	Cowlitz 1981	Fall
			Cowlitz 1982	Fall
			Cowlitz 1988	Fall
		Kalama*	Kalama 1982	Fall
			Kalama 1988	Fall
			Kalama 1989	Fall
		Spring Creek-Big Creek*	Big Creek 1982	Fall
			Spring Creek 1982	Fall
			Spring Creek 1987	Fall
			Spring Creek 1990	Fall
			Big Creek 1990	Fall
		Lewis*	Lewis 1990	Fall
		Sandy*	Sandy 1990	Fall
	Upper Columbia River (Spring)	Warm Springs	Warm Springs 1982	Spring
			Warm Springs 1987	Spring
			Warm Springs 1987	Spring
		Carson*	Carson 1982	Spring
			Carson (At Klickitat) 1989	Spring
			Carson 1989	Spring
		Wenatchee*	Wenatchee 1986	Spring
			Wenatchee 1989	Spring
		Leavenworth	Leaveworth 1982	Spring
			Leaveworth 1986	Spring
		Klickitat*	Klickitat 1989	Spring
			Klickitat 1990	Spring

Table 3. Continued.

Region	Subregion	Population Group	Sampling Location	Runtime
		Round Butte*	Round Butte 1982	Spring
			Round Butte 1990	Spring
		Yakima Cle Elum*	Yakima 1986	Spring
			Cle Elum 1989	Spring
			Yakima 1989	Spring
			Yakima 1990	Spring
		American River*	American River 1986	Spring
			American River 1989	Spring
			American River 1990	Spring
		Naches-Bumping*	Naches 1989	Spring
			Bumping 1989	Spring
			Little Naches 1989	Spring
			Little Naches 1990	Spring
			Naches 1990	Spring
			Bumping 1990	Spring
		John Day	John Day 1985	Spring
		Winthrop	Winthrop 1986	Spring
	Snake River (Spring and Summer)	Rapid River*	Red River 1982	Spring
			Rapid River 1982	Spring
			Rapid River 1985	Spring
			Rapid River 1990	Spring
		Tucannon*	Tucannon 1985	Spring
			Tucannon 1986	Spring
			Tucannon 1987	Spring
			Tucannon 1986	Spring
			Tucannon 1987	Spring
			Tucannon 1988	Spring
			Tucannon 1988	Spring
			Tucannon 1989	Spring
			Tucannon 1990	Spring
			Tucannon 1990	Spring
		Lostine River*	Lostine River 1989	Spring
			Lostine River 1990	Spring
			Lostine River 1991	Spring
		Sawtooth*	Sawtooth 1982	Spring
			Sawtooth 1989	Spring
			Sawtooth 1990	Spring
			Sawtooth 1991	Spring
		McCall*	McCall 1982	Summer
			McCall 1989	Summer
			McCall 1990	Summer
			McCall 1991	Summer
		Secesh River*	Secesh River 1989	Summer
			Secesh River 1990	Summer
			Secesh River 1991	Summer
		Johnson Creek*	Johnson Creek 1982	Summer
			Johnson Creek 1989	Summer
			Johnson Creek 1990	Summer
			Johnson Creek 1991	Summer
		Marsh Creek*	Marsh Creek 1989	Spring
			Marsh Creek 1990	Spring
			Marsh Creek 1991	Spring
		Valley Creek*	Valley Creek 1989	Spring
			Valley Creek 1990	Spring
			Valley Creek 1991	Spring
		Imnaha River*	Imnaha 1989	Summer
			Imnaha 1990	Summer
			Imnaha 1990	Summer
			Imnaha 1991	Summer
			Imnaha 1991	Summer
		Upper Salmon At Blaine Bridge*	Upper Salmon At Blaine Bridge 1989	Spring
		Catherine Creek*	Catherine Creek 1990	Spring
		Minam River*	Minam River 1990	Spring
		Looking Glass*	Looking Glass 1991	Spring
		Upper Salmon, Frenchman Creek*	Upper Salmon, Frenchman Creek 1991	Spring

Table 3. Continued.

Region	Subregion	Population Group	Sampling Location	Runtime
		Upper Salmon, Sawtooth*	Upper Salmon, Sawtooth 1991	Spring
		Chamberlain Creek*	Chamberlain Creek 1991	Spring
	Upper Columbia River (Summer)	Okanagan-Wells	Okanogan 1985	Summer
			Wells 1982	Summer
		Wenatchee*	Wenatchee 1985	Summer
			Wenatchee 1988	Summer
			Wenatchee 1989	Summer
			Wenatchee 1990	Summer
	Upper Columbia and Snake Rivers (Fall)	Bonneville*	Bonneville 1989	Fall
			Bonneville 1990	Fall
		Little White Salmon*	Little White Salmon 1989	Fall
			Little White Salmon 1990	Fall
		Deschutes*	Deschutes 1982	Fall
			Deschutes 1985	Fall
			Deschutes 1990	Fall
		Hanford Reach*	White Bluffs 1982	Fall
			Vernita Bar 1982	Fall
			Hanford Reach 1990	Fall
		Priest Rapids*	Priest Rapids 1981	Fall
			Priest Rapids 1986	Fall
			Priest Rapids 1987	Fall
			Priest Rapids 1990	Fall
		Marion Drain*	Marion Drain 1989	Fall
			Marion Drain 1990	Fall
		Lyons Ferry*	Lyons Ferry 1985	Fall
			Lyons Ferry 1986	Fall
			Lyons Ferry 1987	Fall
			Lyons Ferry 1990	Fall
		Yakima*	Yakima 1990	Fall
3) Washington Coast	North Washington Coastal (Spring and Summer)	Soleduck*	Soleduck 1987	Spring
			Soleduck 1988	Spring
			Soleduck 1990	Spring
		Soleduck	Soleduck 1987	Summer
	Washington Coastal (Fall)	Quinault*	Quinault 1981	Fall
			Quinault 1990	Fall
		Queets*	Queets 1981	Fall
			Queets 1990	Fall
		Hoh*	Hoh 1981	Fall
			Hoh 1982	Fall
			Hoh 1990	Fall
		Naselle*	Naselle 1987	Fall
			Naselle 1988	Fall
			Naselle 1989	Fall
			Naselle 1990	Fall
		Humptulips*	Humptulips 1990	Fall
4) Puget Sound	North Puget Sound (Spring)	North Fork Nooksack*	North Fork Nooksack 1985	Spring
			North Fork Nooksack 1988	Spring
		Suiattle*	Suiattle 1985	Spring
			Suiattle 1986	Spring
			Suiattle 1987	Spring
			Suiattle 1988	Spring
			Suiattle 1989	Spring
			Suiattle 1990	Spring
		Upper Sauk	Upper Sauk 1986	Spring
		Skagit*	Skagit 1990	Spring
	Puget Sound (Summer and Fall)	Deschutes [Percival]*	Deschutes [Percival] 1981	Fall
			Deschutes [Percival] 1987	Fall
		Samish	Samish 1982	Fall
			Samish 1986	Fall
		Elwha*	Elwha 1981	Fall
			Elwha 1988	Fall
		Hoodsport*	Hoodsport 1981	Fall
			Hoodsport 1988	Fall
		North Fork Stilliguamish Summer*	North Fork Stilliguamish 1987	Summer
			North Fork Stillaguamish 1988	Summer
		Bridal Veil*	Bridal Veil 1988	Summer

Table 3. Continued.

Region	Subregion	Population Group	Sampling Location	Runtime
			Bridal Veil 1987	Summer
		Skykomish*	Skykomish 1987	Summer
			Skykomish 1988	Summer
			Skykomish 1989	Summer
		Sultan*	Sultan 1988	Fall
			Sultan 1987	Fall
			Sultan 1989	Fall
		Green River*	Green River 1981	Fall
			Green River 1987	Fall
			Green River 1988	Fall
			Green River 1990	Fall
		Upper Skagit	Upper Skagit 1986	Summer
		Lower Sauk	Lower Sauk 1986	Summer
		Skagit*	Skagit 1988	Summer
		Skykomish*	Skykomish 1987	Fall
		North Fork Nooksack	North Fork Nooksack 1986	Fall
		Lower Skagit 86+87	Lower Skagit 1987	Fall
		Skagit*	Skagit 1987	Fall
		Snoqualmie*	Snoqualmie 1988	Fall
		Wallace*	Wallace 1989	Fall
5) BC: Fraser River	Lower Fraser River (Spring and Summer)	Birkenhead	Birkenhead 1985	Spring
			Birkenhead 1987	Spring
		Pitt River*	Pitt River 1987	Summer
	Lower Fraser River (Fall)	Chilliwack*	Chilliwack 1989	Fall
			Chilliwack 1990	Fall
		Chehalis-Harrison*	Chehalis 1988	Fall
			Chehalis 1989	Fall
			Harrison 1989	Fall
			Chehalis 1990	Fall
	Thompson River (Summer)	Coldwater*	Coldwater 1987	Summer
			Coldwater 1982	Summer
		Salmon*	Salmon 1985	Summer
			Salmon 1987	Summer
			Salmon 1988	Summer
		Eagle	Eagle 1985	Summer
			Eagle 1987	Summer
			Eagle 1988	Summer
		Clearwater-Horseshoe	Clearwater 1985	Summer
			Clearwater 1982	Summer
			Horseshoe 1987	Summer
		North Thompson	North Thompson 1987	Summer
		Nicola	Nicola 1987	Summer
		Raft	Raft 1985	Summer
		Deadman	Deadman 1987	Summer
		Spius*	Spius 1987	Summer
		Bonaparte*	Bonaparte 1987	Summer
		Lower Shuswap	Lower Shuswap 1987	Summer
		Middle Shuswap	Middle Shuswap 1987	Summer
		Adams	Adams 1987	Summer
		White Horse Bluff	White Horse Bluff 1987	Summer
		Finn Creek	Finn Creek 1987	Summer
	Mid-Fraser River (Spring and Summer)	Nechako-Stuart	Nechako 1982	Summer
			Stuart 1982	Summer
		Upper Cariboo*	Upper Cariboo 1985	Spring
			Upper Cariboo 1987	Spring
		Cottonwood	Cottonwood 1985	Spring
			Cottonwood 1987	Spring
		Blackwater	Blackwater 1985	Spring
			Blackwater 1987	Spring
		Baezaeko*	Baezaeko 1985	Spring
			Baezaeko 1987	Spring
		Willow*	Willow 1985	Spring
			Willow 1987	Spring
		Chilko*	Chilko 1982	Summer
			Chilko 1987	Summer

Table 3. Continued.

Region	Subregion	Population Group	Sampling Location	Runtime
			Chilko 1988	Summer
		Quesnel*	Quesnel Red 1985	Spring
			Quesnel White 1985	Spring
			Quesnel White 1987	Spring
			Quesnel Red 1987	Spring
			Quesnel 1988	Spring
			Quesnel 1988	Spring
			Quesnel 1990	Spring
		Chilcotin	Chilcotin 1988	Summer
		Lower Cariboo*	Lower Cariboo 1987	Spring
		Nazko	Nazko 1987	Spring
	Upper Fraser River (Spring)	Tete Jaune*	Tete Jaune 1982	Spring
			Tete Jaune 1988	Spring
		Bowron	Bowron 1985	Spring
			Bowron 1987	Spring
		Seebach	Seebach 1985	Spring
		James	James 1985	Spring
		Fontoniko	Fontoniko 1985	Spring
		Indianpoint	Indianpoint 1985	Spring
		Salmon	Salmon 1987	Spring
		Slim Creek	Slim Creek 1987	Spring
		Walker Creek	Walker Creek 1987	Spring
		Morkill	Morkill 1987	Spring
		Horsey*	Horsey 1987	Spring
		Swift Creek	Swift Creek 1987	Spring
6) BC: Non-Fraser River	West Vancouver Island (Fall)	Sucwoa-Conuma	Sucwoa 1985	Fall
			Conuma 1985	Fall
		Robertson Creek*	Robertson Creek 1981	Fall
			Robertson Creek 1985	Fall
			Robertson Creek 1991	Fall
		Conuma	Conuma 1985	Fall
		Nitinat	Nitinat 1985	Fall
	Upper Georgia Strait (Summer and Fall)	Quinsam*	Quinsam 1981	Fall
			Quinsam 1985	Fall
			Quinsam 1988	Fall
			Quinsam 1989	Fall
			Quinsam 1990	Fall
		Puntledge	Puntledge 1985	Summer
	Lower Georgia Strait (Summer and Fall)	Squamish*	Squamish 1985	Summer
			Squamish 1988	Summer
		Cowichan*	Cowichan 1988	Fall
			Cowichan 1989	Fall
			Cowichan 1990	Fall
		Nanaimo*	Nanaimo 1985	Fall
			Nanaimo 1988	Fall
			Nanaimo 1989	Fall
			Nanaimo 1990	Fall
		Nanaimo Lake*	Nanaimo Lake 1989	Summer
			Nanaimo Lake 1990	Summer
		Big Qualicum*	Big Qualicum 1981	Fall
			Big Qualicum 1985	Fall
			Big Qualicum 1988	Fall
			Big Qualicum 1989	Fall
			Big Qualicum 1990	Fall
	Central BC Coastal (Summer and Fall)	Kitimat*	Kitimat 1985	Summer
			Kitimat 1988	Summer
		Cranberry*	Cranberry 1988	N/A
			Cranberry 1990	N/A
		Wannock*	Wannock 1988	Fall
			Wannock 1991	Fall
		Atnarko*	Atnarko 1985	Spring
			Atnarko 1990	Spring
			Atnarko 1991	Spring
		Bear*	Bear River 1988	Spring
			Bear River 1991	Spring

Table 3. Continued.

Region	Subregion	Population Group	Sampling Location	Runtime
		Kitsumkalum*	Kitsumkalum 1988	Summer
			Kitsumkalum 1989	Summer
			Lower Kitsumkalum 1991	Summer
			Upper Kitsumkalum 1991	Summer
		Bulkley River*	Bulkley River 1989	Spring
			Bulkley River 1991	Spring
		Babine*	Babine 1982	Summer
			Babine 1988	Summer
		Kispiox River*	Kispiox River 1989	N/A
		Damdochax*	Damdochax 1988	N/A
		Fort Babine	Fort Babine 1990	N/A
		Cedar River*	Cedar River 1991	Spring
		Kitwanga River*	Kitwanga River 1991	N/A
		Morice River	Morice River 1991	Spring
	BC / Alaska Transboundary (Spring)	Iskut*	Iskut 1990	Spring
		Little Tahltan*	Little Tahltan 1990	Spring

Table 4. Estimated allele frequencies for collections of Alaska chinook salmon. The following alleles were standardized with allele mobility controls for chinook salmon: *sAAT-1,2*100, *85; sAAT-3*100, *90; mAAT-1*-100, *-77,*-104; mAAT-2*100, *-125; ADA-1*100, *83; GPI-A*100; sIDHP-1*100, *94; sIDHP-2*100, *50; mMDH-2*100, *200; MPI*100, *109; PGK-2*100,*90; sSOD-1*-100,*-260; PEPA*100,*90; PEPB-1*100,*130; PEPLT*100;* and *TPI-4*100, *104.*

	*sAAT-1,2**			*sAAT-3**			*sAAT-4**					*mAAT-1**				*mAAT-2**		
Population	N	*100*	*85*	*114*	N	*100*	*90*	N	*100*	*130*	*63*	*175*	N	*-100*	*-77*	*-104*	N	*-100*	*-125*
Chickamin River-LPW 93	99	0.9975	0.0025	0.0000	98	0.9949	0.0051	79	0.9430	0.0000	0.0570	0.0000	100	1.0000	0.0000	0.0000	100	1.0000	0.0000
Chickamin River-WHL 92	100	0.9825	0.0175	0.0000	98	0.9337	0.0663	95	0.9053	0.0211	0.0737	0.0000	100	0.9750	0.0000	0.0250	100	1.0000	0.0000
Chickamin River-WHL 94	55	0.9864	0.0136	0.0000	55	0.9455	0.0545	52	0.8269	0.0096	0.1635	0.0000	55	0.9455	0.0000	0.0545	55	1.0000	0.0000
Chickamin River J 95	142	0.9595	0.0405	0.0000	148	0.9595	0.0405	143	0.8392	0.0524	0.1084	0.0000	149	0.9799	0.0000	0.0201	149	0.9933	0.0067
Unuk River-DMT 92	100	0.9950	0.0050	0.0000	100	0.8350	0.1650	96	0.8594	0.0052	0.1354	0.0000	100	0.9600	0.0000	0.0400	100	1.0000	0.0000
Unuk River-DMT 94	52	0.9952	0.0048	0.0000	50	0.8800	0.1200	50	0.8500	0.0100	0.1400	0.0000	53	0.9906	0.0000	0.0094	53	1.0000	0.0000
Unuk River-LPW 93	99	0.9975	0.0025	0.0000	98	0.8878	0.1122	91	0.8516	0.0055	0.1429	0.0000	99	0.9899	0.0000	0.0101	99	1.0000	0.0000
Unuk River 94	141	0.9894	0.0106	0.0000	147	0.9422	0.0578	134	0.8993	0.0299	0.0709	0.0000	144	0.9861	0.0000	0.0139	146	0.9966	0.0034
Andrew Creek-CRL 92	100	0.9975	0.0025	0.0000	84	0.8333	0.1667	96	0.7812	0.0000	0.2188	0.0000	99	0.9747	0.0000	0.0253	98	0.9949	0.0051
Andrew Creek-HFL 94	60	0.9875	0.0125	0.0000	60	0.8833	0.1167	54	0.9167	0.0000	0.0833	0.0000	60	0.9667	0.0000	0.0333	60	0.9917	0.0083
Andrew Creek-HFL J 94	59	0.9915	0.0085	0.0000	147	0.8844	0.1156	128	0.8867	0.0039	0.1094	0.0000	148	0.9899	0.0000	0.0101	148	0.9595	0.0405
Farragut River J 93	36	1.0000	0.0000	0.0000	38	1.0000	0.0000	37	0.7568	0.0135	0.2297	0.0000	38	1.0000	0.0000	0.0000	38	1.0000	0.0000
Farragut River 93	50	0.9850	0.0150	0.0000	43	0.9419	0.0581	47	0.8511	0.0000	0.1489	0.0000	50	0.9900	0.0000	0.0100	50	0.9800	0.0200
Farragut River J 94	83	0.9578	0.0422	0.0000	85	1.0000	0.0000	75	0.7800	0.0000	0.2200	0.0000	85	1.0000	0.0000	0.0000	85	0.9588	0.0412
King Salmon River 92	14	1.0000	0.0000	0.0000	14	0.9643	0.0357	14	0.5714	0.0000	0.4286	0.0000	14	1.0000	0.0000	0.0000	14	0.9286	0.0714
King Salmon River-LPW 93	100	1.0000	0.0000	0.0000	93	0.9677	0.0323	95	0.3737	0.0000	0.6263	0.0000	99	1.0000	0.0000	0.0000	98	0.9745	0.0255
Big Boulder Creek 92	21	1.0000	0.0000	0.0000	21	0.9762	0.0238	20	0.9500	0.0000	0.0500	0.0000	21	1.0000	0.0000	0.0000	21	0.9048	0.0952
Big Boulder Creek 93	25	1.0000	0.0000	0.0000	25	0.8800	0.1200	25	0.9800	0.0000	0.0200	0.0000	25	1.0000	0.0000	0.0000	25	0.9800	0.0200
Kelsall River 93	45	1.0000	0.0000	0.0000	42	0.9881	0.0119	43	0.9070	0.0000	0.0930	0.0000	44	1.0000	0.0000	0.0000	44	0.9091	0.0909
Tahini River 92	68	1.0000	0.0000	0.0000	63	0.9921	0.0079	37	0.9324	0.0135	0.0541	0.0000	68	1.0000	0.0000	0.0000	68	0.8897	0.1103
Klutina River 91	20	1.0000	0.0000	0.0000	15	0.7667	0.2333	20	0.8500	0.0000	0.1500	0.0000	20	1.0000	0.0000	0.0000	20	1.0000	0.0000
Gulkana River J 94	90	1.0000	0.0000	0.0000	90	0.7500	0.2500	87	0.7184	0.0000	0.2816	0.0000	90	1.0000	0.0000	0.0000	90	1.0000	0.0000
Kasilof River-CCR 92	82	1.0000	0.0000	0.0000	71	0.8169	0.1831	79	0.8165	0.0000	0.1835	0.0000	80	1.0000	0.0000	0.0000	80	1.0000	0.0000
Kenai River J 93	147	1.0000	0.0000	0.0000	146	0.8185	0.1815	143	0.9930	0.0000	0.0070	0.0000	149	1.0000	0.0000	0.0000	148	1.0000	0.0000
Talachulitna Creek 95	58	1.0000	0.0000	0.0000	58	0.7500	0.2500	55	0.9455	0.0000	0.0455	0.0091	58	1.0000	0.0000	0.0000	58	1.0000	0.0000
Deception Creek 91	93	1.0000	0.0000	0.0000	81	0.8148	0.1852	87	0.9885	0.0000	0.0115	0.0000	101	1.0000	0.0000	0.0000	101	1.0000	0.0000
Moose Creek-Deshka 95	51	1.0000	0.0000	0.0000	51	0.7843	0.2157	50	0.9900	0.0000	0.0100	0.0000	51	1.0000	0.0000	0.0000	50	1.0000	0.0000
Prairie Creek 95	53	1.0000	0.0000	0.0000	51	0.8137	0.1863	52	0.9712	0.0000	0.0288	0.0000	53	1.0000	0.0000	0.0000	53	1.0000	0.0000
Karluk River 93	67	1.0000	0.0000	0.0000	57	0.9649	0.0351	64	0.7500	0.0000	0.2500	0.0000	67	1.0000	0.0000	0.0000	67	1.0000	0.0000
Ayakulik River 93	98	1.0000	0.0000	0.0000	98	0.9286	0.0714	95	0.7263	0.0000	0.2737	0.0000	98	1.0000	0.0000	0.0000	99	1.0000	0.0000
Chignik River 95	45	1.0000	0.0000	0.0000	43	0.8953	0.1047	45	0.9111	0.0111	0.0778	0.0000	46	1.0000	0.0000	0.0000	44	1.0000	0.0000
Nelson Lagoon 95	149	1.0000	0.0000	0.0000	149	0.9329	0.0671	145	0.9897	0.0000	0.0103	0.0000	149	1.0000	0.0000	0.0000	149	1.0000	0.0000
Neknek River 95	98	1.0000	0.0000	0.0000	97	0.8144	0.1856	99	0.9495	0.0000	0.0505	0.0000	98	1.0000	0.0000	0.0000	100	1.0000	0.0000
Stuyahok River 93	36	1.0000	0.0000	0.0000	36	0.8194	0.1806	35	0.9571	0.0000	0.0429	0.0000	36	1.0000	0.0000	0.0000	36	1.0000	0.0000
Stuyahok River 94	51	1.0000	0.0000	0.0000	51	0.8627	0.1373	49	0.9592	0.0000	0.0408	0.0000	51	1.0000	0.0000	0.0000	51	1.0000	0.0000
Nushagak River 93	53	1.0000	0.0000	0.0000	53	0.7358	0.2642	50	0.9500	0.0000	0.0500	0.0000	53	1.0000	0.0000	0.0000	53	1.0000	0.0000
Nushagak River 94	93	1.0000	0.0000	0.0000	97	0.7577	0.2423	96	0.9323	0.0000	0.0677	0.0000	97	1.0000	0.0000	0.0000	97	1.0000	0.0000
Togiak River 93	62	1.0000	0.0000	0.0000	60	0.8000	0.2000	61	0.9836	0.0000	0.0164	0.0000	62	1.0000	0.0000	0.0000	62	1.0000	0.0000
Togiak River 94	100	1.0000	0.0000	0.0000	98	0.7806	0.2194	98	0.9745	0.0000	0.0255	0.0000	98	0.9949	0.0051	0.0000	99	1.0000	0.0000
Goodnews River 93	40	1.0000	0.0000	0.0000	39	0.7692	0.2308	39	0.9872	0.0000	0.0128	0.0000	40	1.0000	0.0000	0.0000	40	1.0000	0.0000
Kanektok River 92	27	1.0000	0.0000	0.0000	28	0.7500	0.2500	26	0.9423	0.0000	0.0577	0.0000	27	0.9815	0.0185	0.0000	27	1.0000	0.0000
Kanektok River 93	46	1.0000	0.0000	0.0000	45	0.8111	0.1889	46	0.9348	0.0000	0.0652	0.0000	46	1.0000	0.0000	0.0000	46	1.0000	0.0000
Tuluksak River 93	50	1.0000	0.0000	0.0000	49	0.7755	0.2245	48	0.9792	0.0000	0.0208	0.0000	50	1.0000	0.0000	0.0000	50	1.0000	0.0000
Kogrukluk River 92	50	1.0000	0.0000	0.0000	47	0.7979	0.2021	49	0.9796	0.0000	0.0204	0.0000	50	1.0000	0.0000	0.0000	50	1.0000	0.0000
Kogrukluk River 93	50	1.0000	0.0000	0.0000	49	0.7857	0.2143	50	0.9800	0.0000	0.0200	0.0000	50	1.0000	0.0000	0.0000	50	1.0000	0.0000
Stony River 94	100	1.0000	0.0000	0.0000	96	0.7969	0.2031	92	0.9783	0.0000	0.0217	0.0000	95	1.0000	0.0000	0.0000	87	1.0000	0.0000
Takotna River 92	13	1.0000	0.0000	0.0000	8	0.6875	0.3125	12	0.9583	0.0000	0.0417	0.0000	13	1.0000	0.0000	0.0000	13	1.0000	0.0000
N. Klondike River J 93	145	0.9948	0.0000	0.0052	149	0.9966	0.0034	149	0.9698	0.0000	0.0302	0.0000	150	1.0000	0.0000	0.0000	150	1.0000	0.0000
Stoney River-Yukon 92	124	1.0000	0.0000	0.0000	118	0.8432	0.1568	121	0.9298	0.0000	0.0702	0.0000	123	1.0000	0.0000	0.0000	123	1.0000	0.0000
Unalakleet River 92	23	1.0000	0.0000	0.0000	23	0.8261	0.1739	20	0.9500	0.0000	0.0500	0.0000	24	1.0000	0.0000	0.0000	24	1.0000	0.0000
Unalakleet River 93	69	1.0000	0.0000	0.0000	70	0.8500	0.1500	55	0.9000	0.0000	0.1000	0.0000	69	1.0000	0.0000	0.0000	68	1.0000	0.0000

Table 4. Continued.

		*ADA-1**			*sAH**				*ALAT**			*GAPDH-2**			*GPIA**				
Population	N	*100*	*83*	N	*100*	*86*	*108*	N	*100*	*90*	N	*100*	*22*	N	*100*	*105*	*93*	*85*
Chickamin River-LPW 93	98	0.9337	0.0663	99	0.9242	0.0758	0.0000	96	0.9740	0.0260	98	0.8112	0.1888	96	0.9948	0.0052	0.0000	0.0000
Chickamin River-WHL 92	100	0.9450	0.0550	99	0.8485	0.1515	0.0000	99	0.9596	0.0404	100	0.9750	0.0250	99	0.9596	0.0303	0.0000	0.0101
Chickamin River-WHL 94	55	0.9455	0.0545	55	0.8545	0.1455	0.0000	55	0.9273	0.0727	50	1.0000	0.0000	55	0.9727	0.0273	0.0000	0.0000
Chickamin River J 95	149	0.9362	0.0638	149	0.8020	0.1980	0.0000	147	0.9286	0.0714	149	0.9799	0.0201	148	0.9764	0.0236	0.0000	0.0000
Unuk River-DMT 92	99	0.9798	0.0202	100	0.9450	0.0550	0.0000	100	0.9700	0.0300	100	0.9850	0.0150	100	0.9900	0.0100	0.0000	0.0000
Unuk River-DMT 94	53	1.0000	0.0000	53	0.9245	0.0755	0.0000	52	0.9904	0.0096	51	0.9902	0.0098	49	0.9490	0.0510	0.0000	0.0000
Unuk River-LPW 93	99	0.9949	0.0051	98	0.9031	0.0969	0.0000	98	0.8622	0.1378	99	0.9949	0.0051	99	0.9495	0.0505	0.0000	0.0000
Unuk River 94	146	0.9623	0.0377	141	0.9043	0.0957	0.0000	145	0.9379	0.0621	145	0.9966	0.0034	145	0.9759	0.0241	0.0000	0.0000
Andrew Creek-CRL 92	100	0.9650	0.0350	100	0.9250	0.0750	0.0000	98	0.8673	0.1327	99	1.0000	0.0000	100	0.9700	0.0300	0.0000	0.0000
Andrew Creek-HFL 94	60	0.9750	0.0250	60	0.9250	0.0750	0.0000	60	0.9250	0.0750	60	1.0000	0.0000	60	1.0000	0.0000	0.0000	0.0000
Andrew Creek-HFL J 94	150	0.9867	0.0133	149	0.9899	0.0101	0.0000	142	0.9049	0.0951	150	0.9933	0.0067	150	0.9833	0.0167	0.0000	0.0000
Farragut River J 93	38	0.8947	0.1053	38	0.9211	0.0789	0.0000	38	0.9211	0.0789	38	1.0000	0.0000	38	1.0000	0.0000	0.0000	0.0000
Farragut River 93	50	1.0000	0.0000	50	0.9300	0.0700	0.0000	50	0.9500	0.0500	50	0.9900	0.0100	50	0.9800	0.0200	0.0000	0.0000
Farragut River J 94	85	0.9412	0.0588	84	0.9881	0.0119	0.0000	84	0.9464	0.0536	85	1.0000	0.0000	84	0.9940	0.0060	0.0000	0.0000
King Salmon River 92	13	0.8077	0.1923	14	0.7500	0.2500	0.0000	14	1.0000	0.0000	14	1.0000	0.0000	14	1.0000	0.0000	0.0000	0.0000
King Salmon River-LPW 93	99	0.5859	0.4141	100	0.8650	0.1350	0.0000	98	1.0000	0.0000	100	1.0000	0.0000	100	1.0000	0.0000	0.0000	0.0000
Big Boulder Creek 92	21	1.0000	0.0000	21	0.9524	0.0476	0.0000	14	1.0000	0.0000	21	1.0000	0.0000	21	1.0000	0.0000	0.0000	0.0000
Big Boulder Creek 93	25	1.0000	0.0000	25	1.0000	0.0000	0.0000	24	1.0000	0.0000	25	1.0000	0.0000	25	1.0000	0.0000	0.0000	0.0000
Kelsall River 93	45	1.0000	0.0000	45	1.0000	0.0000	0.0000	45	1.0000	0.0000	45	0.9889	0.0111	45	0.9778	0.0222	0.0000	0.0000
Tahini River 92	68	1.0000	0.0000	68	1.0000	0.0000	0.0000	69	1.0000	0.0000	66	1.0000	0.0000	68	0.9485	0.0515	0.0000	0.0000
Klutina River 91	20	0.8000	0.2000	20	1.0000	0.0000	0.0000	20	0.9500	0.0500	20	1.0000	0.0000	19	1.0000	0.0000	0.0000	0.0000
Gulkana River J 94	89	0.7528	0.2472	90	1.0000	0.0000	0.0000	90	0.9611	0.0389	86	1.0000	0.0000	90	1.0000	0.0000	0.0000	0.0000
Kasilof River-CCR 92	82	0.9146	0.0854	82	1.0000	0.0000	0.0000	79	0.9620	0.0380	82	1.0000	0.0000	82	1.0000	0.0000	0.0000	0.0000
Kenai River J 93	150	0.9533	0.0467	149	0.9866	0.0134	0.0000	147	0.9932	0.0068	150	1.0000	0.0000	150	1.0000	0.0000	0.0000	0.0000
Talachulitna Creek 95	57	0.8070	0.1930	57	0.9649	0.0351	0.0000	58	0.9828	0.0172	58	1.0000	0.0000	58	1.0000	0.0000	0.0000	0.0000
Deception Creek 91	100	0.8150	0.1850	90	0.9778	0.0222	0.0000	96	0.9948	0.0052	97	1.0000	0.0000	95	1.0000	0.0000	0.0000	0.0000
Moose Creek-Deshka 95	51	0.8922	0.1078	51	1.0000	0.0000	0.0000	51	0.9706	0.0294	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000
Prairie Creek 95	53	0.9434	0.0566	53	0.9906	0.0094	0.0000	52	0.9712	0.0288	53	1.0000	0.0000	53	1.0000	0.0000	0.0000	0.0000
Karluk River 93	64	0.9609	0.0391	67	0.9851	0.0149	0.0000	66	0.9015	0.0985	64	1.0000	0.0000	67	1.0000	0.0000	0.0000	0.0000
Ayakulik River 93	99	0.9848	0.0152	95	1.0000	0.0000	0.0000	99	0.8182	0.1818	98	1.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000
Chignik River 95	42	0.9167	0.0833	43	0.9884	0.0116	0.0000	46	1.0000	0.0000	44	1.0000	0.0000	46	0.9891	0.0000	0.0109	0.0000
Nelson Lagoon 95	148	0.9257	0.0743	145	0.9448	0.0552	0.0000	149	0.9899	0.0101	146	1.0000	0.0000	149	0.9899	0.0000	0.0101	0.0000
Neknek River 95	100	0.8550	0.1450	99	0.9141	0.0859	0.0000	97	0.8918	0.1082	98	1.0000	0.0000	100	1.0000	0.0000	0.0000	0.0000
Stuyahok River 93	36	0.8889	0.1111	36	0.9167	0.0833	0.0000	36	0.9722	0.0278	36	1.0000	0.0000	29	1.0000	0.0000	0.0000	0.0000
Stuyahok River 94	51	0.8824	0.1176	50	0.9100	0.0900	0.0000	51	0.9510	0.0490	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000
Nushagak River 93	52	0.8558	0.1442	52	0.8846	0.1154	0.0000	52	0.9519	0.0481	53	1.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000
Nushagak River 94	97	0.8402	0.1598	97	0.9588	0.0412	0.0000	97	0.8814	0.1186	93	1.0000	0.0000	97	1.0000	0.0000	0.0000	0.0000
Togiak River 93	62	0.8306	0.1694	61	0.9344	0.0656	0.0000	60	0.9667	0.0333	50	1.0000	0.0000	60	1.0000	0.0000	0.0000	0.0000
Togiak River 94	100	0.8150	0.1850	100	0.8850	0.1150	0.0000	100	0.9150	0.0850	100	1.0000	0.0000	100	0.9900	0.0000	0.0100	0.0000
Goodnews River 93	40	0.8375	0.1625	39	0.8846	0.1154	0.0000	33	0.9848	0.0152	40	1.0000	0.0000	40	0.9875	0.0000	0.0125	0.0000
Kanektok River 92	28	0.8571	0.1429	29	0.9655	0.0172	0.0172	27	0.9259	0.0741	27	1.0000	0.0000	28	0.9821	0.0000	0.0179	0.0000
Kanektok River 93	46	0.9348	0.0652	46	0.9891	0.0109	0.0000	43	0.9419	0.0581	45	1.0000	0.0000	45	1.0000	0.0000	0.0000	0.0000
Tuluksak River 93	46	0.8804	0.1196	50	0.9600	0.0400	0.0000	47	0.8936	0.1064	50	1.0000	0.0000	50	1.0000	0.0000	0.0000	0.0000
Kogrukluk River 92	49	0.8265	0.1735	50	0.9300	0.0700	0.0000	47	0.9149	0.0851	50	1.0000	0.0000	49	0.9898	0.0102	0.0000	0.0000
Kogrukluk River 93	50	0.7800	0.2200	50	0.9400	0.0600	0.0000	48	0.9062	0.0938	49	1.0000	0.0000	50	1.0000	0.0000	0.0000	0.0000
Stony River 94	98	0.8724	0.1276	97	0.9485	0.0464	0.0052	91	0.9011	0.0989	97	1.0000	0.0000	96	1.0000	0.0000	0.0000	0.0000
Takotna River 92	12	0.9583	0.0417	13	0.9615	0.0385	0.0000	13	0.8846	0.1154	11	1.0000	0.0000	13	1.0000	0.0000	0.0000	0.0000
N. Klondike River J 93	147	1.0000	0.0000	144	0.9132	0.0000	0.0868	146	0.9315	0.0685	145	1.0000	0.0000	150	1.0000	0.0000	0.0000	0.0000
Stoney River-Yukon 92	105	0.9571	0.0429	124	0.6532	0.3468	0.0000	124	0.9960	0.0040	122	1.0000	0.0000	124	1.0000	0.0000	0.0000	0.0000
Unalakleet River 92	24	0.8542	0.1458	23	0.8478	0.1522	0.0000	24	1.0000	0.0000	23	1.0000	0.0000	24	1.0000	0.0000	0.0000	0.0000
Unalakleet River 93	60	0.8417	0.1583	67	0.9478	0.0522	0.0000	71	0.9718	0.0282	71	1.0000	0.0000	71	0.9789	0.0000	0.0211	0.0000

Table 4. Continued.

Population	GPI-B2*			GPI-B2a*			GPIr*			HAGH*				sIDHP-1*					
	N	*100*	*60*	N	*100*	*24*	N	*100*	***	N	*100*	*143*	*78*	N	*100*	*74*	*94*	*129*	*136*
Chickamin River-LPW 93	95	1.0000	0.0000	95	1.0000	0.0000	96	1.0000	0.0000	97	0.8454	0.1546	0.0000	100	0.7200	0.0000	0.2800	0.0000	0.0000
Chickamin River-WHL 92	100	1.0000	0.0000	100	1.0000	0.0000	100	1.0000	0.0000	99	0.9444	0.0556	0.0000	100	0.9100	0.0000	0.0900	0.0000	0.0000
Chickamin River-WHL 94	55	1.0000	0.0000	55	1.0000	0.0000	55	1.0000	0.0000	55	1.0000	0.0000	0.0000	55	0.9000	0.0000	0.1000	0.0000	0.0000
Chickamin River J 95	142	1.0000	0.0000	142	1.0000	0.0000	148	1.0000	0.0000	144	0.9410	0.0556	0.0035	148	0.8851	0.0000	0.1149	0.0000	0.0000
Unuk River-DMT 92	100	0.9700	0.0300	100	1.0000	0.0000	100	1.0000	0.0000	100	0.9750	0.0250	0.0000	98	0.8265	0.0000	0.1735	0.0000	0.0000
Unuk River-DMT 94	50	1.0000	0.0000	50	1.0000	0.0000	53	1.0000	0.0000	53	0.9906	0.0094	0.0000	53	0.9057	0.0000	0.0943	0.0000	0.0000
Unuk River-LPW 93	96	0.9896	0.0104	96	1.0000	0.0000	97	1.0000	0.0000	92	0.9837	0.0163	0.0000	99	0.8737	0.0000	0.1263	0.0000	0.0000
Unuk River 94	145	1.0000	0.0000	145	1.0000	0.0000	145	1.0000	0.0000	146	0.9726	0.0274	0.0000	143	0.8462	0.0000	0.1538	0.0000	0.0000
Andrew Creek-CRL 92	96	1.0000	0.0000	96	1.0000	0.0000	100	1.0000	0.0000	100	0.9850	0.0150	0.0000	98	0.9235	0.0000	0.0765	0.0000	0.0000
Andrew Creek-HFL 94	60	0.9833	0.0167	60	1.0000	0.0000	60	1.0000	0.0000	60	0.9750	0.0250	0.0000	60	0.8750	0.0000	0.1250	0.0000	0.0000
Andrew Creek-HFL J 94	150	1.0000	0.0000	150	1.0000	0.0000	150	1.0000	0.0000	60	1.0000	0.0000	0.0000	147	0.8844	0.0000	0.1156	0.0000	0.0000
Farragut River J 93	38	1.0000	0.0000	38	1.0000	0.0000	38	1.0000	0.0000	38	0.9737	0.0263	0.0000	38	0.8158	0.0000	0.1842	0.0000	0.0000
Farragut River 93	50	1.0000	0.0000	50	1.0000	0.0000	50	1.0000	0.0000	50	0.9800	0.0200	0.0000	50	0.9100	0.0000	0.0900	0.0000	0.0000
Farragut River J 94	84	1.0000	0.0000	84	1.0000	0.0000	84	1.0000	0.0000	84	1.0000	0.0000	0.0000	85	0.8118	0.0000	0.1882	0.0000	0.0000
King Salmon River 92	14	0.5000	0.5000	14	1.0000	0.0000	14	1.0000	0.0000	14	1.0000	0.0000	0.0000	14	0.9286	0.0000	0.0714	0.0000	0.0000
King Salmon River-LPW 93	100	0.6000	0.4000	100	1.0000	0.0000	100	1.0000	0.0000	100	1.0000	0.0000	0.0000	98	0.8112	0.0000	0.1888	0.0000	0.0000
Big Boulder Creek 92	21	1.0000	0.0000	21	1.0000	0.0000	21	1.0000	0.0000	21	0.9762	0.0238	0.0000	21	0.7619	0.0000	0.2381	0.0000	0.0000
Big Boulder Creek 93	25	1.0000	0.0000	25	1.0000	0.0000	25	1.0000	0.0000	25	1.0000	0.0000	0.0000	25	0.8600	0.0000	0.1400	0.0000	0.0000
Kelsall River 93	45	1.0000	0.0000	45	1.0000	0.0000	45	1.0000	0.0000	45	0.9889	0.0111	0.0000	44	0.7841	0.0000	0.2159	0.0000	0.0000
Tahini River 92	68	1.0000	0.0000	68	1.0000	0.0000	69	1.0000	0.0000	64	1.0000	0.0000	0.0000	69	0.8841	0.0000	0.1159	0.0000	0.0000
Klutina River 91	19	1.0000	0.0000	19	1.0000	0.0000	20	1.0000	0.0000	20	1.0000	0.0000	0.0000	20	0.8750	0.0000	0.1250	0.0000	0.0000
Gulkana River J 94	90	1.0000	0.0000	90	1.0000	0.0000	90	1.0000	0.0000	90	1.0000	0.0000	0.0000	90	0.9778	0.0000	0.0222	0.0000	0.0000
Kasilof River-CCR 92	82	1.0000	0.0000	82	1.0000	0.0000	82	0.9878	0.0122	60	1.0000	0.0000	0.0000	82	1.0000	0.0000	0.0000	0.0000	0.0000
Kenai River J 93	150	1.0000	0.0000	150	1.0000	0.0000	150	1.0000	0.0000	150	1.0000	0.0000	0.0000	150	1.0000	0.0000	0.0000	0.0000	0.0000
Talachulitna Creek 95	58	1.0000	0.0000	58	1.0000	0.0000	58	1.0000	0.0000	58	1.0000	0.0000	0.0000	57	0.9561	0.0000	0.0000	0.0000	0.0439
Deception Creek 91	95	1.0000	0.0000	95	1.0000	0.0000	97	1.0000	0.0000	96	1.0000	0.0000	0.0000	98	0.9847	0.0000	0.0000	0.0000	0.0153
Moose Creek-Deshka 95	51	1.0000	0.0000	51	1.0000	0.0000	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000	0.0000
Prairie Creek 95	53	1.0000	0.0000	53	1.0000	0.0000	53	1.0000	0.0000	53	1.0000	0.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000	0.0000
Karluk River 93	67	1.0000	0.0000	67	1.0000	0.0000	67	1.0000	0.0000	66	1.0000	0.0000	0.0000	67	1.0000	0.0000	0.0000	0.0000	0.0000
Ayakulik River 93	98	1.0000	0.0000	98	1.0000	0.0000	98	1.0000	0.0000	98	1.0000	0.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000	0.0000
Chignik River 95	46	1.0000	0.0000	46	1.0000	0.0000	46	1.0000	0.0000	45	1.0000	0.0000	0.0000	45	1.0000	0.0000	0.0000	0.0000	0.0000
Nelson Lagoon 95	149	1.0000	0.0000	149	1.0000	0.0000	149	1.0000	0.0000	145	1.0000	0.0000	0.0000	144	0.9757	0.0000	0.0000	0.0243	0.0000
Neknek River 95	99	1.0000	0.0000	99	1.0000	0.0000	99	1.0000	0.0000	97	1.0000	0.0000	0.0000	100	0.9900	0.0000	0.0000	0.0100	0.0000
Stuyahok River 93	35	1.0000	0.0000	35	1.0000	0.0000	35	1.0000	0.0000	36	1.0000	0.0000	0.0000	36	1.0000	0.0000	0.0000	0.0000	0.0000
Stuyahok River 94	51	1.0000	0.0000	51	1.0000	0.0000	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000	0.0000
Nushagak River 93	52	1.0000	0.0000	52	1.0000	0.0000	48	1.0000	0.0000	52	0.9904	0.0096	0.0000	53	0.9906	0.0000	0.0094	0.0000	0.0000
Nushagak River 94	97	1.0000	0.0000	97	1.0000	0.0000	97	1.0000	0.0000	98	1.0000	0.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000	0.0000
Togiak River 93	63	1.0000	0.0000	63	1.0000	0.0000	63	1.0000	0.0000	63	1.0000	0.0000	0.0000	63	0.9921	0.0079	0.0000	0.0000	0.0000
Togiak River 94	100	1.0000	0.0000	100	1.0000	0.0000	100	1.0000	0.0000	100	1.0000	0.0000	0.0000	100	0.9800	0.0150	0.0000	0.0050	0.0000
Goodnews River 93	40	1.0000	0.0000	40	1.0000	0.0000	40	1.0000	0.0000	39	1.0000	0.0000	0.0000	39	0.9744	0.0128	0.0000	0.0128	0.0000
Kanektok River 92	28	1.0000	0.0000	28	1.0000	0.0000	28	1.0000	0.0000	31	1.0000	0.0000	0.0000	28	1.0000	0.0000	0.0000	0.0000	0.0000
Kanektok River 93	45	1.0000	0.0000	45	1.0000	0.0000	45	1.0000	0.0000	47	1.0000	0.0000	0.0000	46	0.9783	0.0000	0.0000	0.0217	0.0000
Tuluksak River 93	50	1.0000	0.0000	50	1.0000	0.0000	50	1.0000	0.0000	50	1.0000	0.0000	0.0000	49	0.9898	0.0102	0.0000	0.0000	0.0000
Kogrukluk River 92	49	1.0000	0.0000	49	1.0000	0.0000	49	1.0000	0.0000	49	1.0000	0.0000	0.0000	50	1.0000	0.0000	0.0000	0.0000	0.0000
Kogrukluk River 93	50	1.0000	0.0000	50	1.0000	0.0000	50	1.0000	0.0000	49	1.0000	0.0000	0.0000	49	1.0000	0.0000	0.0000	0.0000	0.0000
Stony River 94	94	1.0000	0.0000	94	1.0000	0.0000	96	1.0000	0.0000	100	1.0000	0.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000	0.0000
Takotna River 92	13	1.0000	0.0000	13	1.0000	0.0000	13	1.0000	0.0000	13	1.0000	0.0000	0.0000	13	1.0000	0.0000	0.0000	0.0000	0.0000
N. Klondike River J 93	150	1.0000	0.0000	150	1.0000	0.0000	150	1.0000	0.0000	145	1.0000	0.0000	0.0000	149	1.0000	0.0000	0.0000	0.0000	0.0000
Stoney River-Yukon 92	124	1.0000	0.0000	124	0.9960	0.0040	124	1.0000	0.0000	124	1.0000	0.0000	0.0000	124	1.0000	0.0000	0.0000	0.0000	0.0000
Unalakleet River 92	24	1.0000	0.0000	24	1.0000	0.0000	24	1.0000	0.0000	24	1.0000	0.0000	0.0000	24	0.9167	0.0000	0.0000	0.0833	0.0000
Unalakleet River 93	71	1.0000	0.0000	71	1.0000	0.0000	71	1.0000	0.0000	63	1.0000	0.0000	0.0000	71	0.9225	0.0141	0.0000	0.0634	0.0000

Table 4. Continued.

		*sIDHP-2**			*LDHB-2**				*mMDH-2**				*sMDHA-1,2**				*sMDHB-1,2**					
Population	N	*100*	*50*	N	*100*	*112*	*71*	N	*100*	*200*	N	*100*	*120*	N	*100*	*121*	*70*	*83*	*92*
Chickamin River-LPW 93	100	1.0000	0.0000	98	1.0000	0.0000	0.0000	70	0.9714	0.0286	100	1.0000	0.0000	100	0.9650	0.0000	0.0350	0.0000	0.0000
Chickamin River-WHL 92	99	0.9798	0.0202	100	1.0000	0.0000	0.0000	99	0.9444	0.0556	100	1.0000	0.0000	99	0.9545	0.0000	0.0455	0.0000	0.0000
Chickamin River-WHL 94	55	0.9909	0.0091	55	1.0000	0.0000	0.0000	55	1.0000	0.0000	55	1.0000	0.0000	55	0.9864	0.0000	0.0136	0.0000	0.0000
Chickamin River J 95	149	0.9597	0.0403	149	1.0000	0.0000	0.0000				149	1.0000	0.0000	149	0.9815	0.0000	0.0185	0.0000	0.0000
Unuk River-DMT 92	100	0.9900	0.0100	100	1.0000	0.0000	0.0000	99	0.9949	0.0051	100	1.0000	0.0000	100	0.9750	0.0000	0.0250	0.0000	0.0000
Unuk River-DMT 94	53	0.9811	0.0189	53	1.0000	0.0000	0.0000	43	1.0000	0.0000	53	1.0000	0.0000	53	0.9953	0.0000	0.0047	0.0000	0.0000
Unuk River-LPW 93	98	1.0000	0.0000	100	1.0000	0.0000	0.0000	99	0.9697	0.0303	99	1.0000	0.0000	99	0.9899	0.0000	0.0101	0.0000	0.0000
Unuk River 94	145	0.9931	0.0069	148	1.0000	0.0000	0.0000				150	1.0000	0.0000	150	0.9833	0.0000	0.0117	0.0000	0.0050
Andrew Creek-CRL 92	100	1.0000	0.0000	99	1.0000	0.0000	0.0000	100	1.0000	0.0000	99	1.0000	0.0000	100	0.9950	0.0000	0.0050	0.0000	0.0000
Andrew Creek-HFL 94	60	1.0000	0.0000	60	1.0000	0.0000	0.0000	60	0.9917	0.0083	60	1.0000	0.0000	60	0.9708	0.0000	0.0292	0.0000	0.0000
Andrew Creek-HFL J 94	145	0.9276	0.0724	150	1.0000	0.0000	0.0000				150	1.0000	0.0000	150	1.0000	0.0000	0.0000	0.0000	0.0000
Farragut River J 93	38	0.8684	0.1316	38	1.0000	0.0000	0.0000	38	0.9342	0.0658	38	1.0000	0.0000	38	1.0000	0.0000	0.0000	0.0000	0.0000
Farragut River 93	50	0.9400	0.0600	50	1.0000	0.0000	0.0000	50	0.9600	0.0400	50	1.0000	0.0000	50	1.0000	0.0000	0.0000	0.0000	0.0000
Farragut River J 94	85	0.9118	0.0882	85	1.0000	0.0000	0.0000	83	0.9398	0.0602	85	1.0000	0.0000	85	1.0000	0.0000	0.0000	0.0000	0.0000
King Salmon River 92	14	1.0000	0.0000	14	1.0000	0.0000	0.0000	14	1.0000	0.0000	14	1.0000	0.0000	14	1.0000	0.0000	0.0000	0.0000	0.0000
King Salmon River-LPW 93	100	1.0000	0.0000	100	1.0000	0.0000	0.0000	100	0.9950	0.0050	100	1.0000	0.0000	100	1.0000	0.0000	0.0000	0.0000	0.0000
Big Boulder Creek 92	21	0.8333	0.1667	21	1.0000	0.0000	0.0000	21	0.9762	0.0238	21	1.0000	0.0000	21	1.0000	0.0000	0.0000	0.0000	0.0000
Big Boulder Creek 93	25	0.8800	0.1200	25	1.0000	0.0000	0.0000	24	0.9583	0.0417	25	1.0000	0.0000	25	1.0000	0.0000	0.0000	0.0000	0.0000
Kelsall River 93	45	0.9111	0.0889	45	1.0000	0.0000	0.0000	45	1.0000	0.0000	45	1.0000	0.0000	45	1.0000	0.0000	0.0000	0.0000	0.0000
Tahini River 92	65	0.9231	0.0769	68	1.0000	0.0000	0.0000	68	1.0000	0.0000	68	1.0000	0.0000	68	1.0000	0.0000	0.0000	0.0000	0.0000
Klutina River 91	20	1.0000	0.0000	20	1.0000	0.0000	0.0000	20	0.8500	0.1500	20	1.0000	0.0000	20	0.9875	0.0125	0.0000	0.0000	0.0000
Gulkana River J 94	94	0.9787	0.0213	90	1.0000	0.0000	0.0000	80	0.9188	0.0812	90	1.0000	0.0000	90	1.0000	0.0000	0.0000	0.0000	0.0000
Kasilof River-CCR 92	82	1.0000	0.0000	77	1.0000	0.0000	0.0000	82	0.9146	0.0854	82	1.0000	0.0000	82	0.9939	0.0061	0.0000	0.0000	0.0000
Kenai River J 93	150	0.9733	0.0267	150	1.0000	0.0000	0.0000				150	1.0000	0.0000	150	0.9950	0.0050	0.0000	0.0000	0.0000
Talachulitna Creek 95	58	1.0000	0.0000	58	1.0000	0.0000	0.0000	58	0.9914	0.0086	58	1.0000	0.0000	58	1.0000	0.0000	0.0000	0.0000	0.0000
Deception Creek 91	90	1.0000	0.0000	81	1.0000	0.0000	0.0000	98	1.0000	0.0000	98	1.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000	0.0000
Moose Creek-Deshka 95	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	51	0.9510	0.0490	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000	0.0000
Prairie Creek 95	51	1.0000	0.0000	52	0.9904	0.0096	0.0000	52	0.9423	0.0577	53	1.0000	0.0000	53	1.0000	0.0000	0.0000	0.0000	0.0000
Karluk River 93	67	0.9851	0.0149	59	1.0000	0.0000	0.0000	66	0.9848	0.0152	67	1.0000	0.0000	67	1.0000	0.0000	0.0000	0.0000	0.0000
Ayakulik River 93	98	1.0000	0.0000	98	1.0000	0.0000	0.0000	98	0.9898	0.0102	98	1.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000	0.0000
Chignik River 95	45	1.0000	0.0000	47	1.0000	0.0000	0.0000	45	1.0000	0.0000	47	1.0000	0.0000	47	1.0000	0.0000	0.0000	0.0000	0.0000
Nelson Lagoon 95	146	0.9829	0.0171	149	1.0000	0.0000	0.0000				149	1.0000	0.0000	149	1.0000	0.0000	0.0000	0.0000	0.0000
Neknek River 95	100	0.9600	0.0400	100	1.0000	0.0000	0.0000	98	0.9592	0.0408	98	1.0000	0.0000	98	1.0000	0.0000	0.0000	0.0000	0.0000
Stuyahok River 93	36	0.9583	0.0417	36	1.0000	0.0000	0.0000	36	0.9722	0.0278	36	1.0000	0.0000	36	0.9931	0.0069	0.0000	0.0000	0.0000
Stuyahok River 94	51	0.9706	0.0294	51	1.0000	0.0000	0.0000	51	0.9412	0.0588	51	1.0000	0.0000	51	1.0000	0.0000	0.0000	0.0000	0.0000
Nushagak River 93	53	0.9528	0.0472	50	0.9900	0.0000	0.0100	53	0.9623	0.0377	53	1.0000	0.0000	53	0.9764	0.0000	0.0000	0.0236	0.0000
Nushagak River 94	98	0.9490	0.0510	98	0.9949	0.0000	0.0051	97	0.9433	0.0567	98	1.0000	0.0000	96	0.9740	0.0104	0.0000	0.0156	0.0000
Togiak River 93	62	0.9677	0.0323	62	1.0000	0.0000	0.0000	62	0.9274	0.0726	63	1.0000	0.0000	63	0.9921	0.0079	0.0000	0.0000	0.0000
Togiak River 94	100	0.9850	0.0150	100	1.0000	0.0000	0.0000	100	0.9100	0.0900	100	0.9950	0.0050	100	0.9925	0.0075	0.0000	0.0000	0.0000
Goodnews River 93	39	0.9872	0.0128	40	1.0000	0.0000	0.0000	40	0.9375	0.0625	40	1.0000	0.0000	40	0.9812	0.0188	0.0000	0.0000	0.0000
Kanektok River 92	28	0.9821	0.0179	28	1.0000	0.0000	0.0000	28	0.9464	0.0536	28	1.0000	0.0000	28	1.0000	0.0000	0.0000	0.0000	0.0000
Kanektok River 93	46	1.0000	0.0000	45	1.0000	0.0000	0.0000	46	0.9130	0.0870	46	1.0000	0.0000	46	1.0000	0.0000	0.0000	0.0000	0.0000
Tuluksak River 93	50	0.8800	0.1200	50	1.0000	0.0000	0.0000	50	0.9600	0.0400	50	1.0000	0.0000	50	1.0000	0.0000	0.0000	0.0000	0.0000
Kogrukluk River 92	50	0.9900	0.0100	49	1.0000	0.0000	0.0000	49	0.9388	0.0612	49	1.0000	0.0000	49	0.9847	0.0153	0.0000	0.0000	0.0000
Kogrukluk River 93	50	0.9600	0.0400	49	1.0000	0.0000	0.0000	49	0.9490	0.0510	50	1.0000	0.0000	50	0.9800	0.0000	0.0000	0.0200	0.0000
Stony River 94	98	0.9694	0.0306	100	1.0000	0.0000	0.0000	96	0.9635	0.0365	97	1.0000	0.0000	100	0.9975	0.0025	0.0000	0.0000	0.0000
Takotna River 92	13	0.9615	0.0385	13	1.0000	0.0000	0.0000	11	0.9545	0.0455	13	1.0000	0.0000	13	0.9808	0.0000	0.0192	0.0000	0.0000
N. Klondike River J 93	149	1.0000	0.0000	150	1.0000	0.0000	0.0000				150	1.0000	0.0000	150	1.0000	0.0000	0.0000	0.0000	0.0000
Stoney River-Yukon 92	123	0.9797	0.0203	124	1.0000	0.0000	0.0000				124	1.0000	0.0000	124	1.0000	0.0000	0.0000	0.0000	0.0000
Unalakleet River 92	24	0.9792	0.0208	24	1.0000	0.0000	0.0000	24	1.0000	0.0000	24	1.0000	0.0000	24	1.0000	0.0000	0.0000	0.0000	0.0000
Unalakleet River 93	71	0.9507	0.0493	71	1.0000	0.0000	0.0000	69	0.9565	0.0435	71	1.0000	0.0000	70	0.9964	0.0036	0.0000	0.0000	0.0000

Table 4. Continued.

		*sMEP-1**			*sMEP-2**			*MPI**					*PEPA**			*PEPB-1**			
Population	N	*100*	*92*	*86*	N	*100*	*78*	N	*100*	*109*	*95*	*85*	N	*100*	*90*	N	*100*	*130*	*71*
Chickamin River-LPW 93	98	0.1020	0.8980	0.0000	99	0.9899	0.0101	98	0.9388	0.0612	0.0000	0.0000	96	0.9896	0.0104	93	0.9462	0.0538	0.0000
Chickamin River-WHL 92	95	0.2421	0.7579	0.0000	98	0.9592	0.0408	100	0.7950	0.1900	0.0000	0.0150	100	0.9750	0.0250	95	0.9368	0.0526	0.0105
Chickamin River-WHL 94	48	0.4375	0.5625	0.0000	54	0.9630	0.0370	55	0.7818	0.2182	0.0000	0.0000	55	0.9636	0.0364	55	0.9727	0.0273	0.0000
Chickamin River J 95	141	0.2979	0.7021	0.0000	146	0.9863	0.0137	148	0.8345	0.1554	0.0034	0.0068	149	0.9933	0.0067	149	0.9597	0.0403	0.0000
Unuk River-DMT 92	86	0.2616	0.7384	0.0000	95	0.9895	0.0105	99	0.7980	0.2020	0.0000	0.0000	100	0.9700	0.0300	98	0.9592	0.0357	0.0051
Unuk River-DMT 94	51	0.2647	0.7353	0.0000	53	1.0000	0.0000	53	0.7358	0.2642	0.0000	0.0000	53	1.0000	0.0000	53	1.0000	0.0000	0.0000
Unuk River-LPW 93	99	0.1717	0.8283	0.0000	100	0.9700	0.0300	96	0.7969	0.2031	0.0000	0.0000	97	0.9278	0.0722	99	0.9949	0.0051	0.0000
Unuk River 94	129	0.2519	0.7481	0.0000	136	0.9412	0.0588	148	0.8041	0.1959	0.0000	0.0000	150	0.9800	0.0200	146	0.9726	0.0274	0.0000
Andrew Creek-CRL 92	99	0.2626	0.7374	0.0000	99	0.8990	0.1010	99	0.7374	0.2626	0.0000	0.0000	100	0.9850	0.0150	99	1.0000	0.0000	0.0000
Andrew Creek-HFL 94	60	0.3167	0.6833	0.0000	60	0.9667	0.0333	56	0.7679	0.2321	0.0000	0.0000	60	0.9667	0.0333	60	1.0000	0.0000	0.0000
Andrew Creek-HFL J 94	58	0.2500	0.7500	0.0000	60	0.9667	0.0333	150	0.7467	0.2500	0.0000	0.0033	149	0.9564	0.0436	145	0.9690	0.0310	0.0000
Farragut River J 93	37	0.2568	0.7432	0.0000	38	1.0000	0.0000	38	0.9079	0.0921	0.0000	0.0000	38	0.9737	0.0263	38	0.9737	0.0263	0.0000
Farragut River 93	48	0.2396	0.7604	0.0000	50	0.9800	0.0200	50	0.8700	0.1300	0.0000	0.0000	50	0.9800	0.0200	50	0.9800	0.0200	0.0000
Farragut River J 94	76	0.3421	0.6579	0.0000	82	1.0000	0.0000	85	0.8706	0.1294	0.0000	0.0000	85	0.9824	0.0176	85	0.9824	0.0176	0.0000
King Salmon River 92	14	0.0000	1.0000	0.0000	14	1.0000	0.0000	13	0.8846	0.1154	0.0000	0.0000	14	0.6786	0.3214	9	1.0000	0.0000	0.0000
King Salmon River-LPW 93	93	0.0000	1.0000	0.0000	99	0.9596	0.0404	100	0.9200	0.0800	0.0000	0.0000	97	0.7732	0.2268	94	1.0000	0.0000	0.0000
Big Boulder Creek 92	21	0.0714	0.9286	0.0000	21	1.0000	0.0000	21	0.6905	0.3095	0.0000	0.0000	21	1.0000	0.0000	21	0.9048	0.0714	0.0238
Big Boulder Creek 93	25	0.0200	0.9800	0.0000	25	0.9600	0.0400	25	0.8400	0.1600	0.0000	0.0000	25	1.0000	0.0000	25	0.9400	0.0600	0.0000
Kelsall River 93	44	0.1136	0.8864	0.0000	45	1.0000	0.0000	45	0.7444	0.2556	0.0000	0.0000	45	1.0000	0.0000	45	0.9000	0.1000	0.0000
Tahini River 92	69	0.0362	0.9638	0.0000	69	0.9855	0.0145	66	0.6894	0.3106	0.0000	0.0000	68	1.0000	0.0000	68	0.9265	0.0735	0.0000
Klutina River 91	20	0.0000	1.0000	0.0000	20	0.9000	0.1000	20	1.0000	0.0000	0.0000	0.0000	19	1.0000	0.0000	20	0.9250	0.0750	0.0000
Gulkana River J 94	93	0.1183	0.8817	0.0000	94	0.8723	0.1277	90	0.9278	0.0722	0.0000	0.0000	90	0.8000	0.2000	88	0.9773	0.0227	0.0000
Kasilof River-CCR 92	81	0.0988	0.8951	0.0062	81	0.7901	0.2099	82	0.9512	0.0488	0.0000	0.0000	82	0.9817	0.0183	82	0.9451	0.0549	0.0000
Kenai River J 93	150	0.0000	0.9933	0.0067	150	0.8867	0.1133	150	0.9533	0.0467	0.0000	0.0000	149	0.9228	0.0772	150	0.9867	0.0133	0.0000
Talachulitna Creek 95	58	0.0086	0.9914	0.0000	58	0.9483	0.0517	58	0.9569	0.0431	0.0000	0.0000	58	0.9310	0.0690	58	0.9828	0.0172	0.0000
Deception Creek 91	98	0.0153	0.9847	0.0000	99	0.8889	0.1111	94	0.9947	0.0053	0.0000	0.0000	81	0.9815	0.0185	94	0.8989	0.0851	0.0160
Moose Creek-Deshka 95	50	0.0000	1.0000	0.0000	50	0.9600	0.0400	51	0.9706	0.0294	0.0000	0.0000	51	0.9804	0.0196	51	0.9706	0.0294	0.0000
Prairie Creek 95	53	0.0000	1.0000	0.0000	53	0.9811	0.0189	52	0.9615	0.0385	0.0000	0.0000	51	1.0000	0.0000	52	0.8750	0.1250	0.0000
Karluk River 93	67	0.0000	1.0000	0.0000	65	0.8462	0.1538	63	0.8333	0.1667	0.0000	0.0000	59	1.0000	0.0000	64	0.9922	0.0078	0.0000
Ayakulik River 93	98	0.0051	0.9949	0.0000	99	0.8485	0.1515	96	0.8854	0.1146	0.0000	0.0000	98	1.0000	0.0000	98	0.9949	0.0051	0.0000
Chignik River 95	43	0.0116	0.9884	0.0000	44	0.9773	0.0227	44	0.9318	0.0682	0.0000	0.0000	45	0.9444	0.0556	43	1.0000	0.0000	0.0000
Nelson Lagoon 95	149	0.0067	0.9933	0.0000	150	0.9600	0.0400	149	0.8859	0.1141	0.0000	0.0000	148	0.9966	0.0034	147	1.0000	0.0000	0.0000
Neknek River 95	100	0.0050	0.9950	0.0000	100	0.9400	0.0600	100	0.9350	0.0650	0.0000	0.0000	100	0.9550	0.0450	98	0.9184	0.0612	0.0204
Stuyahok River 93	36	0.0000	1.0000	0.0000	36	0.8889	0.1111	36	0.9722	0.0278	0.0000	0.0000	36	0.9583	0.0417	36	0.9028	0.0694	0.0278
Stuyahok River 94	51	0.0000	1.0000	0.0000	51	0.9608	0.0392	51	0.9412	0.0588	0.0000	0.0000	50	0.9500	0.0500	51	0.9216	0.0686	0.0098
Nushagak River 93	53	0.0094	0.9906	0.0000	53	0.8491	0.1509	53	0.9340	0.0660	0.0000	0.0000	53	0.9811	0.0189	53	0.9245	0.0660	0.0094
Nushagak River 94	98	0.0102	0.9898	0.0000	98	0.9082	0.0918	97	0.9381	0.0619	0.0000	0.0000	97	0.9227	0.0773	97	0.9485	0.0412	0.0103
Togiak River 93	62	0.0081	0.9919	0.0000	62	0.8871	0.1129	62	0.9032	0.0968	0.0000	0.0000	62	0.9919	0.0081	59	0.8729	0.0847	0.0424
Togiak River 94	100	0.0050	0.9950	0.0000	100	0.8900	0.1100	100	0.9200	0.0800	0.0000	0.0000	99	0.9596	0.0404	98	0.8980	0.0918	0.0102
Goodnews River 93	38	0.0000	1.0000	0.0000	39	0.9487	0.0513	40	0.9250	0.0750	0.0000	0.0000	40	0.9625	0.0375	39	0.8077	0.1282	0.0641
Kanektok River 92	30	0.0167	0.9833	0.0000	28	0.8214	0.1786	29	0.9655	0.0345	0.0000	0.0000	28	0.9821	0.0179	30	0.9167	0.0667	0.0167
Kanektok River 93	46	0.0000	0.9891	0.0109	44	0.9545	0.0455	47	0.9362	0.0638	0.0000	0.0000	46	0.9457	0.0543	46	0.9565	0.0326	0.0109
Tuluksak River 93	50	0.0000	1.0000	0.0000	50	0.9600	0.0400	49	0.8980	0.1020	0.0000	0.0000	49	0.9388	0.0612	50	0.9200	0.0800	0.0000
Kogrukluk River 92	49	0.0102	0.9898	0.0000	49	0.9184	0.0816	50	0.9100	0.0900	0.0000	0.0000	48	0.9375	0.0625	48	0.9583	0.0417	0.0000
Kogrukluk River 93	50	0.0000	1.0000	0.0000	50	0.9400	0.0600	50	0.9500	0.0500	0.0000	0.0000	49	0.9592	0.0408	50	0.9200	0.0800	0.0000
Stony River 94	94	0.0160	0.9840	0.0000	93	0.9032	0.0968	97	0.9227	0.0773	0.0000	0.0000	96	0.9479	0.0521	97	0.9227	0.0670	0.0103
Takotna River 92	11	0.0455	0.9545	0.0000	11	0.8182	0.1818	12	0.9167	0.0833	0.0000	0.0000	13	1.0000	0.0000	12	0.9167	0.0833	0.0000
N. Klondike River J 93	140	0.0500	0.9393	0.0107	143	0.9580	0.0420	146	1.0000	0.0000	0.0000	0.0000	145	0.8103	0.1897	149	1.0000	0.0000	0.0000
Stoney River-Yukon 92	119	0.0210	0.9790	0.0000	115	0.6087	0.3913	125	0.9160	0.0840	0.0000	0.0000	124	1.0000	0.0000	122	1.0000	0.0000	0.0000
Unalakleet River 92	24	0.0000	1.0000	0.0000	24	0.9583	0.0417	24	0.9792	0.0208	0.0000	0.0000	23	0.9783	0.0217	23	0.7391	0.2609	0.0000
Unalakleet River 93	71	0.0070	0.9930	0.0000	67	0.8657	0.1343	70	0.9000	0.1000	0.0000	0.0000	70	0.9571	0.0429	60	0.6750	0.3250	0.0000

Table 4. Continued.

		*PEPD-2**				*PEP-LT**			*PGK-2**				*PGM-2**				*IDDH-1**	
Population	N	*100*	*107*	*83*	N	*100*	*110*	N	*100*	*90*	*74*	N	*100*	*136*	N	*100*	***
Chickamin River-LPW 93	99	1.0000	0.0000	0.0000	97	0.9794	0.0206	97	0.0361	0.9639	0.0000	100	1.0000	0.0000	45	1.0000	0.0000
Chickamin River-WHL 92	100	1.0000	0.0000	0.0000	100	1.0000	0.0000	100	0.1100	0.8900	0.0000	100	1.0000	0.0000	97	0.8814	0.1186
Chickamin River-WHL 94	55	1.0000	0.0000	0.0000	55	0.9273	0.0727	55	0.0455	0.9545	0.0000	55	1.0000	0.0000	54	0.9722	0.0278
Chickamin River J 95	148	1.0000	0.0000	0.0000				148	0.0709	0.9291	0.0000	149	1.0000	0.0000	141	0.9007	0.0993
Unuk River-DMT 92	100	1.0000	0.0000	0.0000	99	0.8889	0.1111	96	0.0833	0.9167	0.0000	100	1.0000	0.0000	98	0.8571	0.1429
Unuk River-DMT 94	53	1.0000	0.0000	0.0000	53	0.9906	0.0094	53	0.0943	0.9057	0.0000	53	1.0000	0.0000	52	0.8269	0.1731
Unuk River-LPW 93	99	1.0000	0.0000	0.0000	97	0.8918	0.1082	98	0.0663	0.9337	0.0000	99	1.0000	0.0000	96	0.9167	0.0833
Unuk River 94	150	1.0000	0.0000	0.0000				148	0.1351	0.8649	0.0000	150	1.0000	0.0000	136	0.8493	0.1507
Andrew Creek-CRL 92	99	1.0000	0.0000	0.0000	100	0.9950	0.0050	98	0.1480	0.8520	0.0000	99	1.0000	0.0000	90	0.8778	0.1222
Andrew Creek-HFL 94	60	1.0000	0.0000	0.0000	59	0.9746	0.0254	60	0.1333	0.8667	0.0000	60	1.0000	0.0000	57	0.8772	0.1228
Andrew Creek-HFL J 94	60	1.0000	0.0000	0.0000				60	0.1000	0.9000	0.0000	149	1.0000	0.0000	139	0.8597	0.1403
Farragut River J 93	38	1.0000	0.0000	0.0000	38	0.9868	0.0132	37	0.0000	1.0000	0.0000	38	1.0000	0.0000	38	0.8289	0.1711
Farragut River 93	48	1.0000	0.0000	0.0000	50	0.9500	0.0500	50	0.1000	0.9000	0.0000	50	1.0000	0.0000	50	0.8500	0.1500
Farragut River J 94	84	1.0000	0.0000	0.0000	84	0.9643	0.0357	85	0.2235	0.7765	0.0000	85	1.0000	0.0000	80	0.8375	0.1625
King Salmon River 92	14	1.0000	0.0000	0.0000	14	1.0000	0.0000	5	0.2000	0.8000	0.0000	12	1.0000	0.0000	14	0.9643	0.0357
King Salmon River-LPW 93	100	1.0000	0.0000	0.0000	97	1.0000	0.0000	100	0.1900	0.8100	0.0000	100	1.0000	0.0000	37	1.0000	0.0000
Big Boulder Creek 92	21	1.0000	0.0000	0.0000	21	0.9286	0.0714	21	0.0000	1.0000	0.0000	21	1.0000	0.0000	21	0.9524	0.0476
Big Boulder Creek 93	25	1.0000	0.0000	0.0000	24	0.9583	0.0417	25	0.0000	1.0000	0.0000	25	1.0000	0.0000	25	0.9400	0.0600
Kelsall River 93	45	1.0000	0.0000	0.0000	45	0.9556	0.0444	45	0.0000	1.0000	0.0000	45	1.0000	0.0000	45	0.9889	0.0111
Tahini River 92	68	1.0000	0.0000	0.0000	65	0.9615	0.0385	68	0.0000	1.0000	0.0000	69	1.0000	0.0000	38	0.9079	0.0921
Klutina River 91	20	1.0000	0.0000	0.0000	20	1.0000	0.0000	20	0.0250	0.9750	0.0000	20	1.0000	0.0000	19	0.9737	0.0263
Gulkana River J 94	89	1.0000	0.0000	0.0000	90	1.0000	0.0000	90	0.0444	0.9556	0.0000	88	1.0000	0.0000	89	0.9270	0.0730
Kasilof River-CCR 92	82	0.9695	0.0000	0.0305	82	1.0000	0.0000	87	0.0000	0.9655	0.0345	81	1.0000	0.0000	74	0.9122	0.0878
Kenai River J 93	150	1.0000	0.0000	0.0000				150	0.0000	0.9833	0.0167	150	1.0000	0.0000	149	0.7919	0.2081
Talachulitna Creek 95	58	0.9655	0.0000	0.0345	58	0.9655	0.0345	58	0.0345	0.9655	0.0000	58	1.0000	0.0000	57	0.9298	0.0702
Deception Creek 91	101	0.9901	0.0000	0.0099	98	0.9949	0.0051	98	0.0510	0.8724	0.0765	98	1.0000	0.0000	89	0.9944	0.0056
Moose Creek-Deshka 95	51	0.9412	0.0196	0.0392	51	0.9706	0.0294	35	0.0143	0.9714	0.0143	51	1.0000	0.0000	51	0.9902	0.0098
Prairie Creek 95	53	1.0000	0.0000	0.0000	52	0.9615	0.0385	53	0.0000	1.0000	0.0000	53	1.0000	0.0000	52	0.9615	0.0385
Karluk River 93	66	1.0000	0.0000	0.0000	67	1.0000	0.0000	66	0.0000	0.9621	0.0379	66	1.0000	0.0000	64	0.8203	0.1797
Ayakulik River 93	98	1.0000	0.0000	0.0000	98	1.0000	0.0000	97	0.0000	0.9691	0.0309	98	1.0000	0.0000	91	0.9341	0.0659
Chignik River 95	46	1.0000	0.0000	0.0000	46	1.0000	0.0000	45	0.0000	1.0000	0.0000	46	1.0000	0.0000	44	0.7614	0.2386
Nelson Lagoon 95	149	1.0000	0.0000	0.0000				147	0.0238	0.9762	0.0000	149	1.0000	0.0000	144	0.6806	0.3194
Neknek River 95	99	1.0000	0.0000	0.0000	99	0.9798	0.0202	99	0.0000	1.0000	0.0000	99	1.0000	0.0000	98	0.9235	0.0765
Stuyahok River 93	36	1.0000	0.0000	0.0000	36	1.0000	0.0000	36	0.0000	1.0000	0.0000	36	1.0000	0.0000	34	0.9265	0.0735
Stuyahok River 94	51	1.0000	0.0000	0.0000	51	1.0000	0.0000	51	0.0000	1.0000	0.0000	51	1.0000	0.0000	50	0.9400	0.0600
Nushagak River 93	53	1.0000	0.0000	0.0000	50	1.0000	0.0000	53	0.0094	0.9906	0.0000	53	0.9811	0.0189	48	0.9583	0.0417
Nushagak River 94	97	1.0000	0.0000	0.0000	97	0.9948	0.0052	97	0.0000	1.0000	0.0000	98	0.9949	0.0051	85	0.9765	0.0235
Togiak River 93	62	1.0000	0.0000	0.0000	62	0.9919	0.0081	62	0.0000	1.0000	0.0000	63	1.0000	0.0000	58	0.9569	0.0431
Togiak River 94	100	1.0000	0.0000	0.0000	100	0.9950	0.0050	96	0.0000	1.0000	0.0000	100	1.0000	0.0000	83	0.9639	0.0361
Goodnews River 93	40	1.0000	0.0000	0.0000	38	0.9737	0.0263	40	0.0000	1.0000	0.0000	40	1.0000	0.0000	38	0.9342	0.0658
Kanektok River 92	22	1.0000	0.0000	0.0000	26	1.0000	0.0000	28	0.0179	0.9821	0.0000	28	0.9821	0.0179	28	0.9821	0.0179
Kanektok River 93	45	1.0000	0.0000	0.0000	43	1.0000	0.0000	43	0.0000	1.0000	0.0000	45	1.0000	0.0000	43	0.9535	0.0465
Tuluksak River 93	48	1.0000	0.0000	0.0000	46	1.0000	0.0000	50	0.0000	1.0000	0.0000	50	1.0000	0.0000	50	0.9700	0.0300
Kogrukluk River 92	47	1.0000	0.0000	0.0000	49	1.0000	0.0000	50	0.0000	1.0000	0.0000	49	1.0000	0.0000	49	0.9490	0.0510
Kogrukluk River 93	50	1.0000	0.0000	0.0000	50	1.0000	0.0000	50	0.0000	1.0000	0.0000	50	1.0000	0.0000	50	0.9700	0.0300
Stony River 94	89	1.0000	0.0000	0.0000	90	0.9722	0.0278	100	0.0000	1.0000	0.0000	100	1.0000	0.0000	91	0.9725	0.0275
Takotna River 92	12	1.0000	0.0000	0.0000	13	1.0000	0.0000	13	0.0000	1.0000	0.0000	11	1.0000	0.0000	11	0.9545	0.0455
N. Klondike River J 93	150	1.0000	0.0000	0.0000				149	0.0000	1.0000	0.0000	149	1.0000	0.0000	139	1.0000	0.0000
Stoney River-Yukon 92	124	1.0000	0.0000	0.0000				125	0.0000	1.0000	0.0000	125	1.0000	0.0000	119	0.9790	0.0210
Unalakleet River 92	24	1.0000	0.0000	0.0000	24	1.0000	0.0000	24	0.0000	1.0000	0.0000	24	1.0000	0.0000	24	0.9167	0.0833
Unalakleet River 93	61	1.0000	0.0000	0.0000	60	1.0000	0.0000	71	0.0000	1.0000	0.0000	71	1.0000	0.0000	66	0.9621	0.0379

Table 4. Continued.

	*mSOD-1**			*sSOD-1**				*TPI-3**			*TPI-4**				Heterozygosity			
Population	N	*100*	*50*	N	*-100*	*-260*	*580*	N	*100*	*96*	N	*100*	*104*	*75*	Obs.	S.D.	Exp.	S.D.
Chickamin River-LPW 93	99	1.0000	0.0000	97	0.8454	0.1546	0.0000	99	1.0000	0.0000	99	1.0000	0.0000	0.0000	0.0759	0.0181	0.0748	0.0004
Chickamin River-WHL 92	99	1.0000	0.0000	100	0.8450	0.1450	0.0100	98	0.9490	0.0510	97	1.0000	0.0000	0.0000	0.0978	0.0196	0.1003	0.0006
Chickamin River-WHL 94	55	1.0000	0.0000	55	0.8818	0.1182	0.0000	55	0.9273	0.0727	55	1.0000	0.0000	0.0000	0.0898	0.0225	0.0905	0.0008
Chickamin River J 95				149	0.7483	0.2517	0.0000	148	0.9257	0.0743	149	1.0000	0.0000	0.0000	0.1027	0.0235	0.1067	0.0004
Unuk River-DMT 92	100	0.9950	0.0050	100	0.9250	0.0750	0.0000	100	0.9600	0.0400	100	0.9950	0.0000	0.0050	0.0850	0.0172	0.0904	0.0005
Unuk River-DMT 94	53	1.0000	0.0000	53	0.9717	0.0283	0.0000	44	0.9659	0.0341	53	1.0000	0.0000	0.0000	0.0759	0.0183	0.0776	0.0007
Unuk River-LPW 93	99	0.9848	0.0152	98	0.8929	0.1071	0.0000	99	0.9747	0.0253	99	1.0000	0.0000	0.0000	0.0793	0.0156	0.0835	0.0005
Unuk River 94	145	0.8586	0.1414	145	0.8586	0.1414	0.0000	147	0.9524	0.0476	148	1.0000	0.0000	0.0000	0.0859	0.0182	0.0902	0.0003
Andrew Creek-CRL 92	99	0.9747	0.0253	97	0.9536	0.0258	0.0206	98	0.9235	0.0765	98	1.0000	0.0000	0.0000	0.0868	0.0205	0.0933	0.0005
Andrew Creek-HFL 94	60	0.9833	0.0167	60	0.9417	0.0583	0.0000	60	0.9583	0.0417	60	1.0000	0.0000	0.0000	0.0847	0.0183	0.0873	0.0008
Andrew Creek-HFL J 94				147	0.8844	0.1156	0.0000	146	0.9384	0.0616	150	1.0000	0.0000	0.0000	0.0909	0.0212	0.0901	0.0004
Farragut River J 93				37	0.7973	0.2027	0.0000	38	0.9211	0.0789	38	1.0000	0.0000	0.0000	0.0943	0.0259	0.0928	0.0012
Farragut River 93	50	0.9900	0.0100	49	0.8878	0.1122	0.0000	50	0.9500	0.0500	50	1.0000	0.0000	0.0000	0.0803	0.0152	0.0808	0.0010
Farragut River J 94				83	0.7771	0.2229	0.0000	85	0.9824	0.0176	85	1.0000	0.0000	0.0000	0.1018	0.0315	0.0986	0.0005
King Salmon River 92	14	1.0000	0.0000	14	0.9286	0.0714	0.0000	14	1.0000	0.0000	14	0.9643	0.0357	0.0000	0.0904	0.0289	0.0925	0.0029
King Salmon River-LPW 93	93	1.0000	0.0000	100	0.9550	0.0450	0.0000	100	0.9950	0.0050	100	0.9350	0.0650	0.0000	0.0883	0.0307	0.0852	0.0003
Big Boulder Creek 92	21	1.0000	0.0000	20	0.8750	0.1250	0.0000	21	1.0000	0.0000	21	0.9762	0.0238	0.0000	0.0695	0.0167	0.0722	0.0017
Big Boulder Creek 93	25	1.0000	0.0000	25	0.8600	0.1400	0.0000	25	1.0000	0.0000	24	0.9792	0.0208	0.0000	0.0491	0.0097	0.0512	0.0012
Kelsall River 93	45	1.0000	0.0000	45	0.7778	0.2222	0.0000	45	1.0000	0.0000	45	0.9778	0.0222	0.0000	0.0704	0.0195	0.0691	0.0008
Tahini River 92	68	1.0000	0.0000	67	0.7985	0.2015	0.0000	68	1.0000	0.0000	68	1.0000	0.0000	0.0000	0.0642	0.0171	0.0621	0.0006
Klutina River 91	20	0.9500	0.0500	20	1.0000	0.0000	0.0000	20	1.0000	0.0000	20	0.9750	0.0250	0.0000	0.0538	0.0146	0.0525	0.0014
Gulkana River J 94				90	0.9833	0.0167	0.0000	90	1.0000	0.0000	90	0.5833	0.4167	0.0000	0.0881	0.0295	0.0895	0.0004
Kasilof River-CCR 92	79	0.9810	0.0190	82	1.0000	0.0000	0.0000	82	1.0000	0.0000	82	0.8780	0.1220	0.0000	0.0572	0.0113	0.0576	0.0004
Kenai River J 93				150	0.9733	0.0267	0.0000	150	1.0000	0.0000	150	0.9833	0.0167	0.0000	0.0389	0.0078	0.0398	0.0002
Talachulitna Creek 95	58	0.9483	0.0517	57	0.9211	0.0789	0.0000	58	1.0000	0.0000	58	0.8534	0.1466	0.0000	0.0618	0.0136	0.0617	0.0006
Deception Creek 91	98	0.8520	0.1480	96	0.9844	0.0156	0.0000	99	1.0000	0.0000	99	0.8283	0.1717	0.0000	0.0521	0.0128	0.0502	0.0003
Moose Creek-Deshka 95	51	0.8725	0.1275	51	0.9804	0.0196	0.0000	51	1.0000	0.0000	51	0.8137	0.1863	0.0000	0.0404	0.0085	0.0420	0.0005
Prairie Creek 95	51	0.7549	0.2451	52	0.9519	0.0481	0.0000	52	1.0000	0.0000	52	0.9135	0.0865	0.0000	0.0361	0.0062	0.0383	0.0005
Karluk River 93	66	0.9924	0.0076	66	1.0000	0.0000	0.0000	66	1.0000	0.0000	66	0.9318	0.0682	0.0000	0.0478	0.0109	0.0501	0.0004
Ayakulik River 93	98	0.9949	0.0051	98	1.0000	0.0000	0.0000	97	1.0000	0.0000	96	0.9271	0.0729	0.0000	0.0459	0.0116	0.0454	0.0002
Chignik River 95	43	0.7674	0.2326	44	0.9659	0.0341	0.0000	47	1.0000	0.0000	44	0.9886	0.0114	0.0000	0.0404	0.0079	0.0410	0.0006
Nelson Lagoon 95				146	0.9795	0.0205	0.0000	149	1.0000	0.0000	149	0.6846	0.3154	0.0000	0.0560	0.0162	0.0545	0.0002
Neknek River 95	98	0.9235	0.0765	95	0.9684	0.0316	0.0000	100	1.0000	0.0000	100	0.8650	0.1350	0.0000	0.0654	0.0132	0.0616	0.0004
Stuyahok River 93	36	0.9722	0.0278	36	0.9306	0.0694	0.0000	36	1.0000	0.0000	36	0.8889	0.1111	0.0000	0.0541	0.0096	0.0545	0.0010
Stuyahok River 94	51	0.9510	0.0490	51	0.9804	0.0196	0.0000	51	1.0000	0.0000	51	0.9118	0.0882	0.0000	0.0477	0.0072	0.0489	0.0007
Nushagak River 93	53	0.9528	0.0472	51	0.9216	0.0784	0.0000	53	1.0000	0.0000	53	0.8679	0.1321	0.0000	0.0672	0.0132	0.0682	0.0008
Nushagak River 94	95	0.9211	0.0789	97	0.9278	0.0722	0.0000	93	1.0000	0.0000	90	0.9000	0.1000	0.0000	0.0669	0.0131	0.0650	0.0004
Togiak River 93	61	0.9426	0.0574	62	0.9839	0.0161	0.0000	62	1.0000	0.0000	62	0.9274	0.0726	0.0000	0.0535	0.0105	0.0525	0.0005
Togiak River 94	99	0.9495	0.0505	100	0.9750	0.0250	0.0000	100	1.0000	0.0000	100	0.9000	0.1000	0.0000	0.0626	0.0131	0.0622	0.0004
Goodnews River 93	40	0.9375	0.0625	40	0.9625	0.0375	0.0000	40	1.0000	0.0000	40	0.8500	0.1500	0.0000	0.0689	0.0169	0.0669	0.0009
Kanektok River 92	27	0.9444	0.0556	29	0.9310	0.0690	0.0000	29	1.0000	0.0000	29	0.9310	0.0690	0.0000	0.0547	0.0109	0.0555	0.0012
Kanektok River 93	47	0.8830	0.1170	47	0.9468	0.0532	0.0000	45	1.0000	0.0000	45	0.9000	0.1000	0.0000	0.0490	0.0083	0.0463	0.0007
Tuluksak River 93	47	0.9681	0.0319	50	0.9200	0.0800	0.0000	50	1.0000	0.0000	50	0.9500	0.0500	0.0000	0.0608	0.0114	0.0601	0.0007
Kogrukluk River 92	49	0.8980	0.1020	48	0.9792	0.0208	0.0000	46	1.0000	0.0000	49	0.8878	0.1122	0.0000	0.0544	0.0090	0.0571	0.0007
Kogrukluk River 93	50	0.8500	0.1500	50	0.9800	0.0200	0.0000	50	1.0000	0.0000	50	0.9400	0.0600	0.0000	0.0547	0.0104	0.0550	0.0006
Stony River 94	98	0.9541	0.0459	98	0.9592	0.0408	0.0000	99	1.0000	0.0000	97	0.8814	0.1186	0.0000	0.0518	0.0088	0.0549	0.0004
Takotna River 92	11	0.9545	0.0455	12	1.0000	0.0000	0.0000	11	1.0000	0.0000	11	0.9545	0.0455	0.0000	0.0600	0.0179	0.0535	0.0026
N. Klondike River J 93				149	1.0000	0.0000	0.0000	150	1.0000	0.0000	150	0.8167	0.1833	0.0000	0.0343	0.0081	0.0354	0.0001
Stoney River-Yukon 92				124	1.0000	0.0000	0.0000	124	1.0000	0.0000	124	1.0000	0.0000	0.0000	0.0419	0.0128	0.0396	0.0002
Unalakleet River 92	23	0.9130	0.0870	23	0.9130	0.0870	0.0000	24	1.0000	0.0000	24	0.8958	0.1042	0.0000	0.0777	0.0231	0.0676	0.0015
Unalakleet River 93	59	0.9576	0.0424	71	0.8803	0.1197	0.0000	61	1.0000	0.0000	67	0.8881	0.1119	0.0000	0.0786	0.0208	0.0763	0.0006

Table 5. Hierarchical log-likelihood heterogeneity analysis of Alaska chinook salmon populations.

Source	DF	*sAAT-1,2**	DF	*sAAT-3**	DF	*sAAT-4**	DF	*mAAT-1**	DF	*mAAT-2**	DF	*ADA-1**	DF	*sAH**	DF	*ALAT**	DF	*GAPDH-2**
Among regions	2	101.25	1	116.06	3	86.68	2	35.04	1	113.24	1	60.22	2	29.29	1	2.57	1	27.17
Within regions	68	54.75	34	225.93	102	390.26	68	21.73	34	49.44	34	267.53	68	583.58	34	222.59	34	8.95
Southeast	12	38.73	6	15.23	18	48.86	12	9.64	6	49.44	6	38.03	12	90.38	6	36.29	6	8.95
Among	6	38.73	3	2.92	9	42.98	6	9.64	3	44.53	3	38.03	6	82.19	3	36.29	3	6.44
Within	6	0.00	3	12.31	9	5.87	6	0.00	3	4.90	3	0.00	6	8.18	3	0.00	3	2.50
Chilkat River	6	0.00	3	12.31	9	5.87	6	0.00	3	4.90	3	0.00	6	8.18	3	0.00	3	2.50
Among	4	0.00	2	8.93	6	5.25	4	0.00	2	2.27	2	0.00	4	4.99	2	0.00	2	2.50
Within (Big Boulder Creek)	2	0.00	1	3.37	3	0.62	2	0.00	1	2.62	1	0.00	2	3.18	1	0.00	1	0.00
Western	56	16.02	28	210.70	84	341.40	56	12.09	28	0.00	28	229.50	56	493.20	28	186.30	28	0.00
Among	18	12.30	9	140.10	27	300.80	18	6.84	9	0.00	9	163.90	18	285.60	9	136.50	9	0.00
Within	38	3.71	19	70.61	57	40.56	38	5.24	19	0.00	19	65.55	38	207.46	19	49.67	19	0.00
Copper River	2	0.00	1	0.03	3	3.22	2	0.00	1	0.00	1	0.41	2	0.00	1	0.09	1	0.00
Cook Inlet	8	0.00	4	2.82	12	11.26	8	0.00	4	0.00	4	35.49	8	6.12	4	5.45	4	0.00
Among	2	0.00	1	0.78	3	3.94	2	0.00	1	0.00	1	21.52	2	0.24	1	1.77	1	0.00
Within (Susitna)	6	0.00	3	2.04	9	7.31	6	0.00	3	0.00	3	13.98	6	5.88	3	3.67	3	0.00
Kodiak Island	2	0.00	1	1.87	3	0.22	2	0.00	1	0.00	1	1.80	2	3.54	1	4.54	1	0.00
Peninsula	2	0.00	1	1.25	3	12.89	2	0.00	1	0.00	1	0.07	2	3.78	1	1.62	1	0.00
Bristol Bay	12	0.00	6	7.81	18	7.24	12	3.24	6	0.00	6	4.09	12	9.68	6	16.54	6	0.00
Among	4	0.00	2	0.78	6	5.70	4	2.26	2	0.00	2	2.36	4	1.18	2	3.03	2	0.00
Within	8	0.00	4	7.00	12	1.52	8	0.98	4	0.00	4	1.70	8	8.48	4	13.49	4	0.00
Nushagak River	6	0.00	3	6.84	9	1.22	6	0.00	3	0.00	3	1.58	6	6.25	3	9.90	3	0.00
Among	2	0.00	1	6.08	3	0.86	2	0.00	1	0.00	1	1.45	2	0.62	1	5.03	1	0.00
Within	4	0.00	2	0.76	6	0.36	4	0.00	2	0.00	2	0.13	4	5.63	2	4.87	2	0.00
Stuyahok River	2	0.00	1	0.59	3	0.00	2	0.00	1	0.00	1	0.01	2	0.02	1	0.51	1	0.00
Nushagak River	2	0.00	1	0.17	3	0.36	2	0.00	1	0.00	1	0.12	2	5.61	1	4.36	1	0.00
Togiak River	2	0.00	1	0.16	3	0.30	2	0.98	1	0.00	1	0.12	2	2.23	1	3.59	1	0.00
Kanektok River	2	0.00	1	0.76	3	0.03	2	2.00	1	0.00	1	2.36	2	2.02	1	0.13	1	0.00
Kuskokwim River	6	0.00	3	0.22	9	0.01	6	0.00	3	0.00	3	5.30	6	3.02	3	0.26	3	0.00
Among	4	0.00	2	0.18	6	0.01	4	0.00	2	0.00	2	4.62	4	2.93	2	0.22	2	0.00
Within (Kogrukluk River)	2	0.00	1	0.04	3	0.00	2	0.00	1	0.00	1	0.67	2	0.08	1	0.04	1	0.00
Yukon River	2	3.71	1	55.71	3	4.67	2	0.00	1	0.00	1	15.99	2	175.10	1	18.69	1	0.00
Unalakleet River	2	0.00	1	0.14	3	1.02	2	0.00	1	0.00	1	0.04	2	4.20	1	2.35	1	0.00
Total	70	156.00	35	342.04	105	476.96	70	56.77	35	162.67	35	327.72	70	612.83	35	225.14	35	36.12

Table 5. Continued.

Source	DF	*GPI-A**	DF	*GPI-B2**	DF	*GPI-B2a**	DF	*HAGH**	DF	*sIDHP-1**	DF	*sIDHP-2**	DF	*LDH-B2**	DF	*sMDH-A1,2**	DF	*sMDH-B1,2**
Among regions	2	75.19	1	48.21	1	0.39	2	85.06	4	413.31	1	17.22	2	1.22	1	0.80	4	86.37
Within regions	68	52.46	34	106.20	34	5.66	68	29.00	136	236.82	34	133.31	68	18.20	34	12.21	136	149.97
Southeast	12	9.14	6	106.20	6	0.00	12	21.61	24	10.62	6	36.62	12	0.00	6	0.00	24	24.37
Among	6	1.58	3	106.20	3	0.00	6	17.89	12	4.74	3	33.69	6	0.00	3	0.00	12	24.37
Within	6	7.56	3	0.00	3	0.00	6	3.72	12	5.88	3	2.93	6	0.00	3	0.00	12	0.00
Chilkat River	6	7.56	3	0.00	3	0.00	6	3.72	12	5.88	3	2.93	6	0.00	3	0.00	12	0.00
Among	4	7.56	2	0.00	2	0.00	4	2.14	8	4.42	2	2.52	4	0.00	2	0.00	8	0.00
Within (Big Boulder Creek)	2	0.00	1	0.00	1	0.00	2	1.58	4	1.45	1	0.40	2	0.00	1	0.00	4	0.00
Western	56	43.32	28	0.00	28	5.66	56	7.39	112	226.20	28	96.69	56	18.20	28	12.21	112	125.60
Among	18	30.04	9	0.00	9	4.07	18	2.87	36	171.70	9	42.77	18	9.07	9	5.76	36	57.75
Within	38	13.25	19	0.00	19	1.58	38	4.52	76	54.51	19	53.88	38	9.11	19	6.43	76	67.89
Copper River	2	0.00	1	0.00	1	0.00	2	0.00	4	6.65	1	1.55	2	0.00	1	0.00	4	3.42
Cook Inlet	8	0.00	4	0.00	4	0.00	8	0.00	16	17.81	4	15.83	8	4.04	4	0.00	16	6.04
Among	2	0.00	1	0.00	1	0.00	2	0.00	4	7.40	1	15.83	2	0.96	1	0.00	4	6.04
Within (Susitna)	6	0.00	3	0.00	3	0.00	6	0.00	12	10.40	3	0.00	6	3.08	3	0.00	12	0.00
Kodiak Island	2	0.00	1	0.00	1	0.00	2	0.00	4	0.00	1	3.62	2	0.00	1	0.00	4	0.00
Peninsula	2	0.00	1	0.00	1	0.00	2	0.00	4	3.84	1	2.70	2	0.00	1	0.00	4	0.00
Bristol Bay	12	6.35	6	0.00	6	0.00	12	4.52	24	19.71	6	5.05	12	5.07	6	6.43	24	37.85
Among	4	4.46	2	0.00	2	0.00	4	1.48	8	15.38	2	3.18	4	3.00	2	4.48	8	21.21
Within	8	1.88	4	0.00	4	0.00	8	3.03	16	4.33	4	1.86	8	2.07	4	1.95	16	16.63
Nushagak River	6	0.00	3	0.00	3	0.00	6	3.03	12	3.01	3	0.82	6	2.07	3	0.00	12	16.63
Among	2	0.00	1	0.00	1	0.00	2	0.91	4	0.91	1	0.62	2	1.85	1	0.00	4	10.90
Within	4	0.00	2	0.00	2	0.00	4	2.12	8	2.10	2	0.20	4	0.22	2	0.00	8	5.73
Stuyahok River	2	0.00	1	0.00	1	0.00	2	0.00	4	0.00	1	0.18	2	0.00	1	0.00	4	1.76
Nushagak River	2	0.00	1	0.00	1	0.00	2	2.12	4	2.10	1	0.02	2	0.22	1	0.00	4	3.97
Togiak River	2	1.88	1	0.00	1	0.00	2	0.00	4	1.32	1	1.04	2	0.00	1	1.95	4	0.00
Kanektok River	2	1.92	1	0.00	1	0.00	2	0.00	4	1.91	1	1.95	2	0.00	1	0.00	4	0.00
Kuskokwim River	6	3.22	3	0.00	3	0.00	6	0.00	12	3.23	3	14.36	6	0.00	3	0.00	12	19.99
Among	4	1.81	2	0.00	2	0.00	4	0.00	8	3.23	2	12.39	4	0.00	2	0.00	8	10.30
Within (Kogrukluk River)	2	1.41	1	0.00	1	0.00	2	0.00	4	0.00	1	1.97	2	0.00	1	0.00	4	9.68
Yukon River	2	0.00	1	0.00	1	1.58	2	0.00	4	0.00	1	7.99	2	0.00	1	0.00	4	0.00
Unalakleet River	2	1.76	1	0.00	1	0.00	2	0.00	4	1.36	1	0.83	2	0.00	1	0.00	4	0.59
Total	70	127.65	35	154.38	35	6.05	70	114.07	140	650.16	35	150.53	70	19.42	35	13.01	140	236.39

Table 5. Continued.

Source	DF	*sMEP-1**	DF	*sMEP-2**	DF	*MPI**	DF	*PEPA**	DF	*PEPB-1**	DF	*PEPD-2**	DF	*PGK-2**	DF	*PGM-2**	DF	*IDDH-1**
Among regions	2	370.23	1	69.54	3	156.62	1	25.88	2	6.56	2	4.90	2	120.02	1	1.61	1	2.85
Within regions	68	229.01	34	257.19	102	142.19	34	297.38	68	373.10	68	64.61	68	275.06	34	21.25	34	391.80
Southeast	12	89.11	6	20.29	18	25.59	6	52.28	12	18.00	12	0.00	12	63.36	6	0.00	6	23.50
Among	6	81.93	3	14.99	9	20.68	3	52.28	6	13.08	6	0.00	6	63.36	3	0.00	3	16.97
Within	6	7.18	3	5.30	9	4.90	3	0.00	6	4.92	6	0.00	6	0.00	3	0.00	3	6.53
Chilkat River	6	7.18	3	5.30	9	4.90	3	0.00	6	4.92	6	0.00	6	0.00	3	0.00	3	6.53
Among	4	5.69	2	2.82	6	2.01	2	0.00	4	3.27	4	0.00	4	0.00	2	0.00	2	6.46
Within (Big Boulder Creek)	2	1.48	1	2.47	3	2.89	1	0.00	2	1.64	2	0.00	2	0.00	1	0.00	1	0.06
Western	56	139.90	28	236.90	84	116.60	28	245.10	56	355.10	56	64.61	56	211.70	28	21.25	28	368.30
Among	18	99.80	9	85.95	27	54.16	9	110.30	18	296.80	18	38.93	18	149.50	9	10.87	9	255.20
Within	38	40.06	19	150.91	57	62.37	19	134.82	38	58.29	38	25.68	38	62.12	19	10.37	19	113.06
Copper River	2	9.06	1	0.24	3	5.39	1	15.22	2	2.28	2	0.00	2	0.35	1	0.00	1	1.37
Cook Inlet	8	12.02	4	17.96	12	8.93	4	21.97	8	38.18	8	25.68	8	51.55	4	0.00	4	81.31
Among	2	7.66	1	5.55	3	2.53	1	10.17	2	17.30	2	10.93	2	16.74	1	0.00	1	69.15
Within (Susitna)	6	4.34	3	12.40	9	6.40	3	11.80	6	20.88	6	14.75	6	34.81	3	0.00	3	12.17
Kodiak Island	2	1.04	1	0.00	3	1.73	1	0.00	2	0.09	2	0.00	2	0.11	1	0.00	1	9.57
Peninsula	2	0.18	1	0.64	3	1.67	1	9.87	2	0.00	2	0.00	2	3.77	1	0.00	1	2.16
Bristol Bay	12	2.90	6	12.37	18	4.50	6	12.05	12	10.70	12	0.00	12	4.47	6	8.45	6	7.50
Among	4	0.04	2	4.17	6	2.59	2	3.09	4	4.45	4	0.00	4	1.47	2	4.46	2	3.65
Within	8	2.85	4	8.18	12	1.89	4	8.94	8	6.23	8	0.00	8	2.99	4	3.98	4	3.84
Nushagak River	6	2.74	3	8.18	9	1.63	3	5.45	6	2.84	6	0.00	6	2.99	3	3.98	3	3.76
Among	2	2.74	1	2.51	3	0.63	1	0.22	2	1.20	2	0.00	2	0.91	1	2.74	1	2.98
Within	4	0.00	2	5.67	6	1.00	2	5.23	4	1.64	4	0.00	4	2.08	2	1.24	2	0.78
Stuyahok River	2	0.00	1	3.35	3	0.98	1	0.06	2	0.79	2	0.00	2	0.00	1	0.00	1	0.12
Nushagak River	2	0.00	1	2.32	3	0.02	1	5.17	2	0.85	2	0.00	2	2.08	1	1.24	1	0.66
Togiak River	2	0.11	1	0.00	3	0.26	1	3.49	2	3.39	2	0.00	2	0.00	1	0.00	1	0.08
Kanektok River	2	2.86	1	6.75	3	0.65	1	1.33	2	1.04	2	0.00	2	1.87	1	1.92	1	0.89
Kuskokwim River	6	4.42	3	3.67	9	2.14	3	0.60	6	5.35	6	0.00	6	0.00	3	0.00	3	1.09
Among	4	3.01	2	3.32	6	0.89	2	0.13	4	4.08	4	0.00	4	0.00	2	0.00	2	0.53
Within (Kogrukluk River)	2	1.41	1	0.35	3	1.24	1	0.46	2	1.27	2	0.00	2	0.00	1	0.00	1	0.56
Yukon River	2	7.00	1	105.60	3	33.49	1	73.31	2	0.00	2	0.00	2	0.00	1	0.00	1	7.79
Unalakleet River	2	0.58	1	3.68	3	3.87	1	0.47	2	0.65	2	0.00	2	0.00	1	0.00	1	1.38
Total	70	599.24	35	326.72	105	298.78	35	323.28	70	379.66	70	69.51	70	395.04	35	22.86	35	394.63

Table 5. Continued.

Source	DF	*sSOD-1**	DF	*TPI-3**	DF	*TPI-4**	DF	Overall	*P*	
Among regions	1	252.99	1	123.50	1	186.09	50	2620.20	0.0000	**
Within regions	34	140.92	34	35.92	34	370.63	1700	5168.10	0.0000	**
Southeast	6	17.62	6	35.92	6	15.33	300	905.10	0.0000	**
Among	3	14.84	3	35.92	3	10.78	150	815.00	0.0000	**
Within	3	2.77	3	0.00	3	4.55	150	90.05	1.0000	
Chilkat River	3	2.77	3	0.00	3	4.55	150	90.05	1.0000	
Among	2	2.73	2	0.00	2	4.54	100	68.17	0.9938	
Within (Big Boulder Creek)	1	0.04	1	0.00	1	0.00	50	21.88	0.9998	
Western	28	123.30	28	0.00	28	355.30	1400	4263.00	0.0000	**
Among	9	92.05	9	0.00	9	141.70	450	2705.00	0.0000	**
Within	19	31.25	19	0.00	19	213.62	950	1557.25	0.0000	**
Copper River	1	1.21	1	0.00	1	29.76	50	80.33	0.0042	**
Cook Inlet	4	9.44	4	0.00	4	53.41	200	425.40	0.0000	**
Among	1	0.66	1	0.00	1	47.94	50	247.20	0.0000	**
Within (Susitna)	3	8.78	3	0.00	3	5.47	150	178.20	0.0578	
Kodiak Island	1	0.00	1	0.00	1	0.02	50	28.20	0.9945	
Peninsula	1	0.49	1	0.00	1	48.32	50	93.33	0.0002	**
Bristol Bay	6	13.94	6	0.00	6	4.50	300	215.10	0.9999	
Among	2	8.57	2	0.00	2	2.62	100	103.70	0.3801	
Within	4	5.34	4	0.00	4	1.86	200	111.35	3.6187	
Nushagak River	3	5.05	3	0.00	3	1.14	150	89.35	2.6189	
Among	1	2.33	1	0.00	1	0.23	50	45.80	0.6425	
Within	2	2.72	2	0.00	2	0.91	100	43.55	1.9764	
Stuyahok River	1	2.69	1	0.00	1	0.24	50	11.37	1.0000	
Nushagak River	1	0.03	1	0.00	1	0.67	50	32.18	0.9764	
Togiak River	1	0.29	1	0.00	1	0.72	50	22.00	0.9998	
Kanektok River	1	0.15	1	0.00	1	0.43	50	31.07	0.9836	
Kuskokwim River	3	5.63	3	0.00	3	5.84	150	78.41	1.0000	
Among	2	5.63	2	0.00	2	4.09	100	57.42	0.9998	
Within (Kogrukluk River)	1	0.00	1	0.00	1	1.74	50	20.99	0.9999	
Yukon River	1	0.00	1	0.00	1	71.32	50	582.00	0.0000	**
Unalakleet River	1	0.39	1	0.00	1	0.02	50	23.41	0.9995	
Total	35	393.94	35	159.42	35	556.77	1750	7787.80	0.0000	**

Table 6. Gene diversity analysis (Nei 1973) of wild chinook salmon populations in Alaska.

			Relative Diversity			
	Absolute	Diversity	Within	Among Collections Within	Among Drainages Within	Among
Locus	H_t	H_s	Collections	Drainages	Regions	Regions
*sAAT-3**	0.2591	0.2458	0.9490	0.0080	0.0210	0.0230
*sAAT-4**	0.1463	0.1295	0.8850	0.0060	0.1010	0.0080
*mAAT-1**	0.0032	0.0031	0.9840	0.0030	0.0100	0.0020
*mAAT-2**	0.0219	0.0202	0.9220	0.0120	0.0190	0.0460
*ADA-1**	0.1946	0.1845	0.9480	0.0070	0.0330	0.0110
*sAH**	0.1234	0.1120	0.9080	0.0270	0.0630	0.0020
*ALAT**	0.0901	0.0863	0.9580	0.0060	0.0320	0.0040
*GAPDH-2**	0.0019	0.0019	0.9850	0.0030	0.0080	0.0040
*GPI-A**	0.0118	0.0116	0.9780	0.0110	0.0040	0.0070
*GPI-B2a**	0.0002	0.0002	0.9961	0.0020	0.0019	0.0000
*HAGH**	0.0072	0.0070	0.9670	0.0030	0.0180	0.0120
*sIDHP-1**	0.0829	0.0742	0.8950	0.0120	0.0200	0.0730
*sIDHP-2**	0.0623	0.0593	0.9530	0.0120	0.0240	0.0120
*LDH-B2**	0.0014	0.0014	0.9920	0.0060	0.0030	0.0000
*sMEP-1**	0.0616	0.0529	0.8590	0.0120	0.0760	0.0520
*MPI**	0.1695	0.1581	0.9330	0.0090	0.0160	0.0420
*PEPA**	0.0876	0.0792	0.9040	0.0280	0.0680	0.0000
*PEPB-1**	0.1345	0.1251	0.9300	0.0070	0.0630	0.0010
*PEPD-2**	0.0057	0.0055	0.9640	0.0170	0.0190	0.0010
*PGK-2**	0.0438	0.0399	0.9130	0.0100	0.0610	0.0160
*PGM-2**	0.0023	0.0023	0.9840	0.0100	0.0060	0.0000
*IDDH-1**	0.1291	0.1198	0.9280	0.0050	0.0680	0.0000
*sSOD-1**	0.1174	0.1095	0.9330	0.0070	0.0180	0.0430
*TPI-3**	0.0068	0.0063	0.9390	0.0000	0.0470	0.0140
*TPI-4**	0.1719	0.1572	0.9150	0.0340	0.0330	0.0180
Overall	1.9364	1.7929	0.9259	0.0123	0.0426	0.0192

Table 7. Log likelihood ratio statistics used to compare allele frequencies within and among hatcheries in Southeast Alaska.

a.) Interannual

	Likelihood	df	*P*
Chickamin River-WHL	63.86	27	0.0001
Unuk River-DMT	48.04	26	0.0053
Andrew Creek-HFL	80.49	26	0.0000

b.) Between Hatcheries

	Likelihood	df	*P*
Chickamin River broodstock	259.3	27	0.0000
Unuk River broodstock	75.27	26	0.0000
Andrew Creek broodstock	104.3	27	0.0000

c.) Between Hatchery and Wildstock

	Likelihood	df	*P*
Chickamin River-WHL	66.88	30	0.0001
Chickamin River-LPW	260.51	27	0.0000
Unuk River-DMT	89.98	28	0.0000
Unuk River-LPW	77.34	26	0.0000
King Salmon River	23.77	15	0.0691

Table 8. Mean estimated contriubtion for 100 simulations (standard deviation in brackets) where each region comprises 100% of the mixture (N=400).

	Regional Allocation							
Mixture Source	Western Alaska	Southeast Alaska	BC: Non Fraser River	BC: Fraser River	Puget Sound	Washington Coast	Columbia River	California - Oregon
Western Alaska	**0.9833**	0.0075	0.0016	0.0001	0.0000	0.0000	0.0035	0.0035
	[0.0126]	[0.0099]	[0.0027]	[0.0006]	[0.0002]	[0.0000]	[0.0044]	[0.0053]
Southeast Alaska	0.0256	**0.9090**	0.0474	0.0058	0.0002	0.0001	0.0015	0.0101
	[0.0182]	**[0.0447]**	[0.0352]	[0.0068]	[0.0007]	[0.0008]	[0.0027]	[0.0122]
BC: Non Fraser River	0.0033	0.0296	**0.9002**	0.0257	0.0086	0.0023	0.0129	0.0173
	[0.0043]	[0.0261]	**[0.0338]**	[0.0191]	[0.0102]	[0.0051]	[0.0098]	[0.0143]
BC: Fraser River	0.0019	0.0047	0.0372	**0.9331**	0.0054	0.0021	0.0053	0.0101
	[0.0028]	[0.0057]	[0.0219]	**[0.0260]**	[0.0078]	[0.0051]	[0.0059]	[0.0106]
Puget Sound	0.0009	0.0013	0.0147	0.0129	**0.9375**	0.0090	0.0099	0.0135
	[0.0016]	[0.0027]	[0.0121]	[0.0112]	**[0.0269]**	[0.0131]	[0.0099]	[0.0128]
Washington Coast	0.0005	0.0016	0.0113	0.0098	0.0459	**0.8417**	0.0333	0.0556
	[0.0013]	[0.003]	[0.0104]	[0.009]	[0.0381]	**[0.0568]**	[0.0222]	[0.033]
Columbia River	0.0019	0.0028	0.0090	0.0023	0.0028	0.0049	**0.9367**	0.0394
	[0.0031]	[0.0055]	[0.0100]	[0.0037]	[0.0043]	[0.0084]	**[0.0297]**	[0.0254]
California - Oregon	0.0030	0.0024	0.0121	0.0013	0.0022	0.0140	0.0203	**0.9445**
	[0.0041]	[0.0043]	[0.0152]	[0.0022]	[0.0040]	[0.0212]	[0.0201]	**[0.0326]**

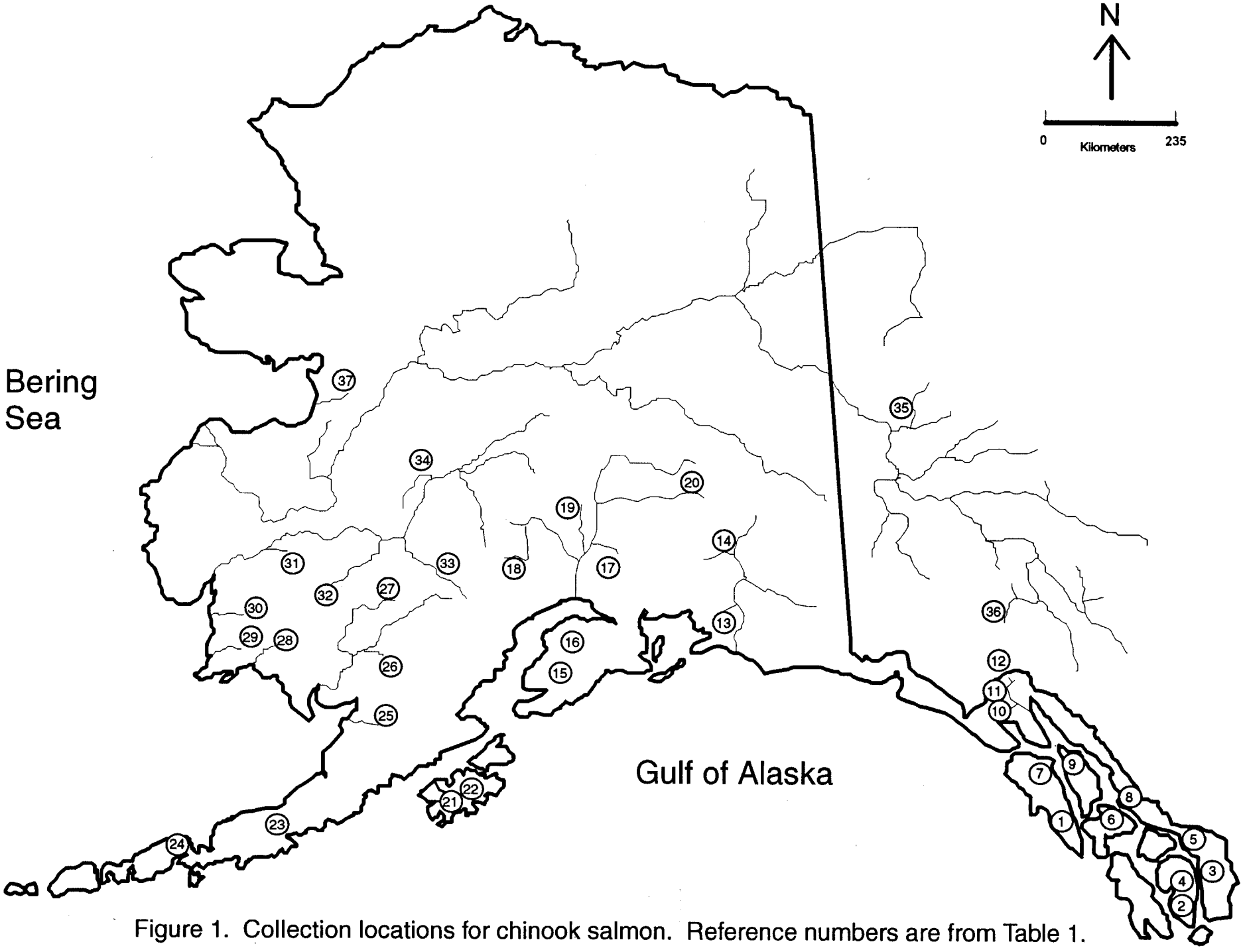

Figure 1. Collection locations for chinook salmon. Reference numbers are from Table 1.

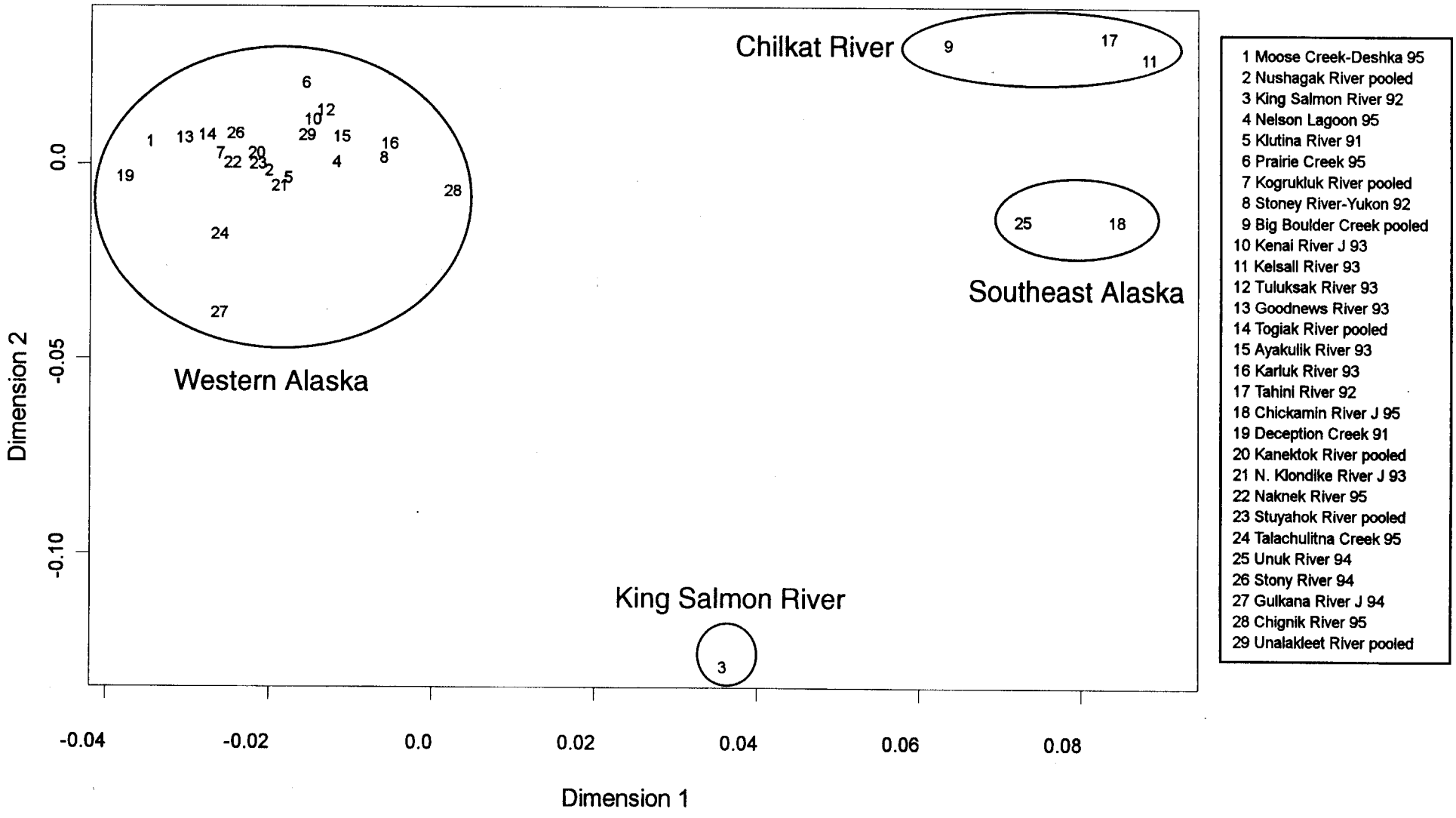

Figure 2. Multidimensional scaling analysis of chinook salmon populations from Southeast Alaska and Western Alaska. Cavalli-Sforza and Edwards chord distances were used.

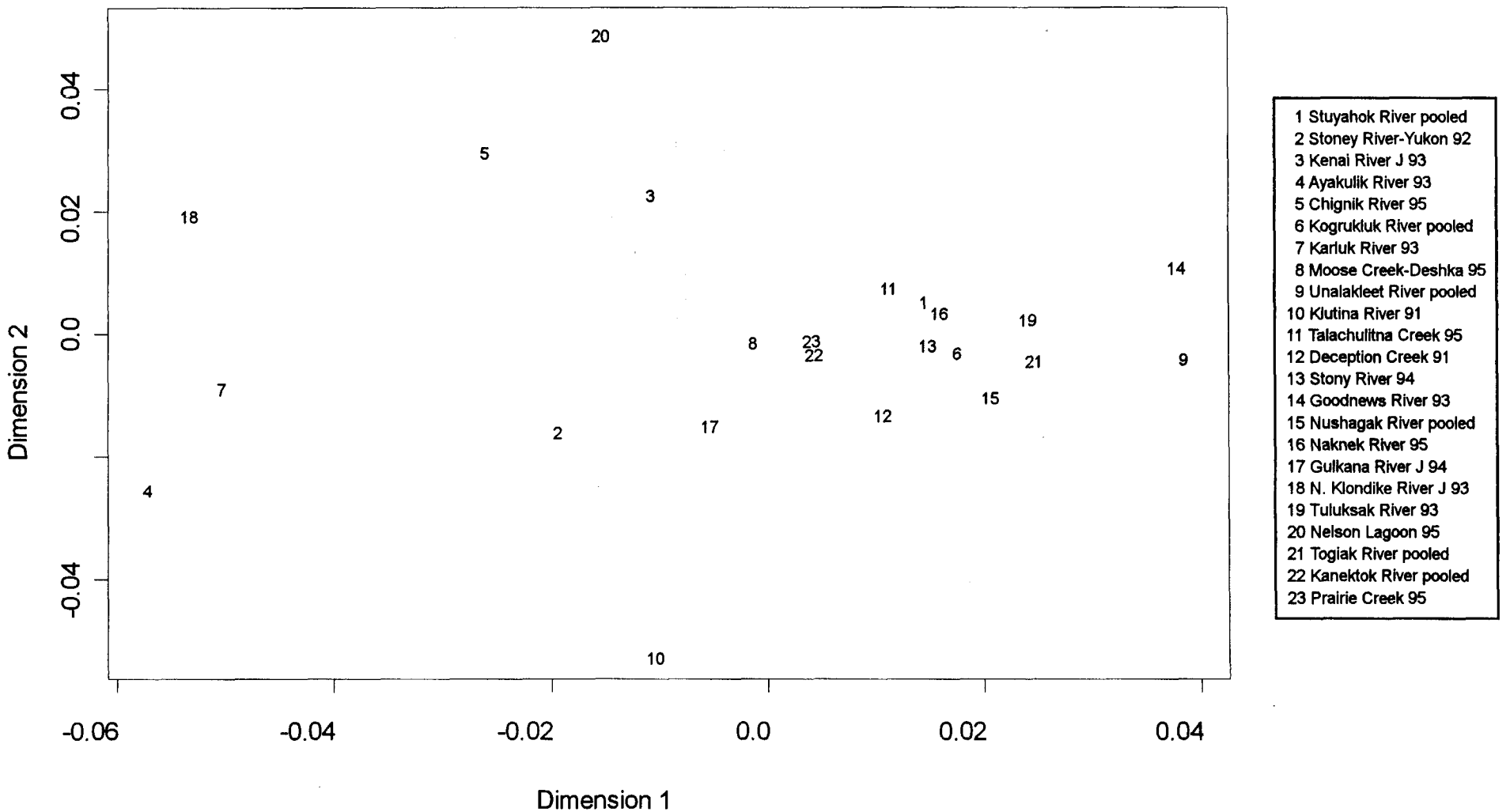

Figure 3. Multidimensional scaling analysis of chinook salmon populations from Western Alaska only. Cavalli-Sforza and Edwards chord distances were used.

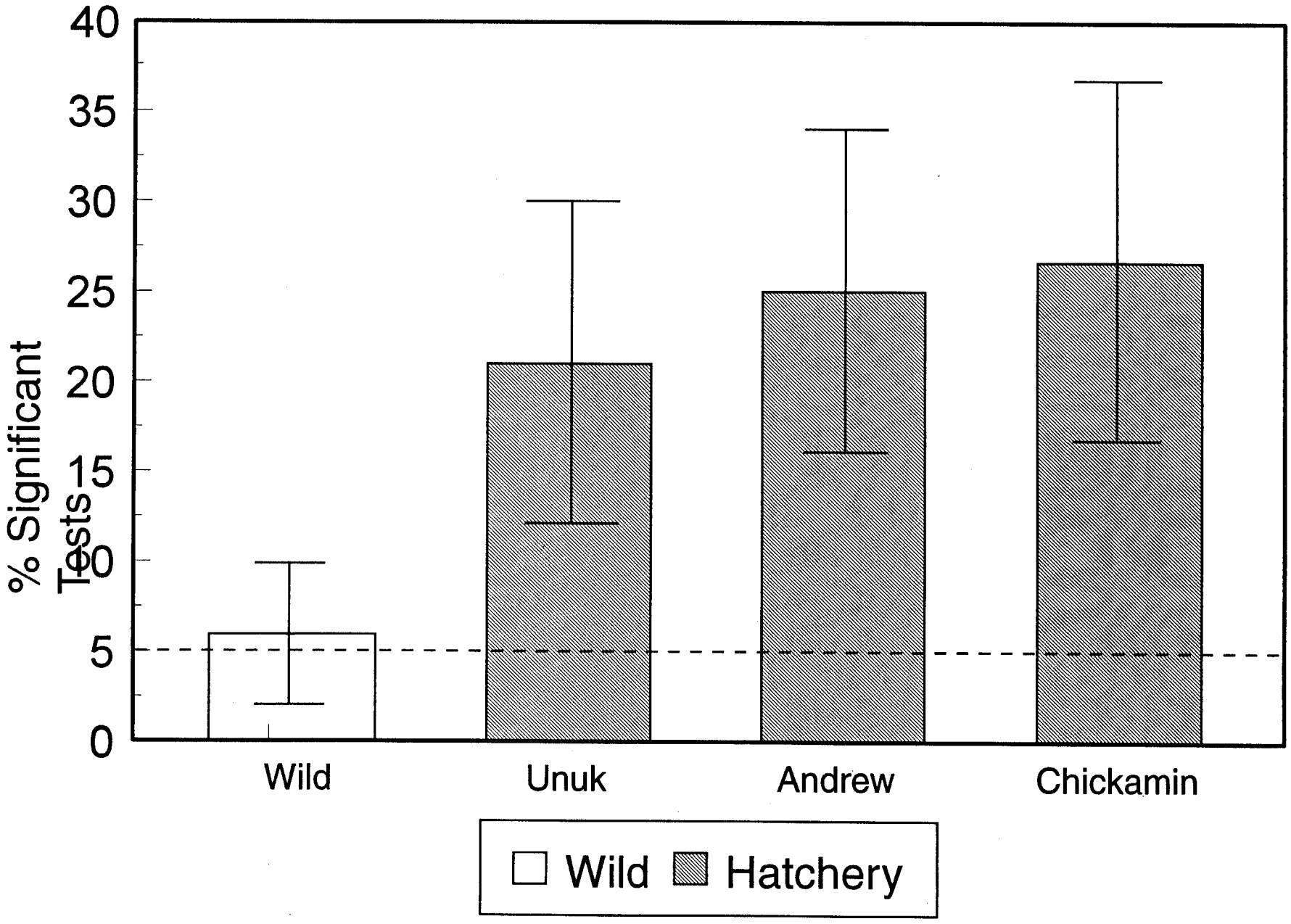

Figure 4. Percent significant temporal allele frequency differences among wild collections and among collections from three hatchery sources. Five percent of tests are expected to be significant by chance alone. Error bars indicate the precision of the estimated percent of significant tests.

Appendix 1. Development of a microsatellite screen for chinook salmon.

Background

An additional objective of this study was to contribute to the development of DNA markers for stock identification of chinook salmon. Recent work suggests that microsatellites, short sequence repeats of nuclear DNA, hold considerable potential for genetic studies of salmonid populations (see review in Wright and Bentzen 1994). They are highly abundant throughout the nuclear eukaryotic genome, and each microsatellite is flanked by a unique sequence. If the sequence is known, the microsatellite can be amplified by the polymerase chain reaction (PCR).

Research to date suggests that microsatellites generally follow Mendelian inheritance and are expressed as codominant genotypes (Estoup et al. 1993; Hedgecock et al. 1996; O'Reilly et al. 1996). Microsatellites are susceptible to length mutations which lead to a high level of heterozygosity (Wright and Bentzen 1994). They often contain more alleles per locus than the average allozyme markers, and because they are noncoding, they are assumed to be selectively neutral. Further, microsatellites developed for one species frequently amplify in related species.

An advantage of microsatellites is that they can be amplified through the polymerase chain reaction (PCR) so that only minute quantities of tissues are necessary. The DNA can be adequately preserved by drying or storage in alcohol. This allows for use of fin-clips, scale samples, or even archived material, and removes the necessity for lethal sampling.

Our objective in this study is to: 1) determine if microsatellite data support major lineages derived from allozyme data and 2) investigate whether microsatellite data can be used to separate populations within lineages. Here we report our progress to date on the development of a microsatellite

screen for chinook salmon. In the future, we plan to screen 50 individuals from selected populations included in the larger allozyme survey.

Progress to Date

We chose to pursue an automated approach to the analysis of microsatellites utilizing an ABI 373A DNA sequencer and associated software (ABI Applied Biosystems, Foster City, CA). This allows detection of multiple loci in a single lane utilizing a fluorescent four-color dye system (Ziegle et al. 1992). One color is devoted to an internal lane standard leaving three colors available for labeling primers. Loci can also be separated based on size in addition to color. Band sizes are called automatically from the known standards.

We identified 13 collections for analysis (Table 1) from the full set of populations included in the allozyme study. DNA was extracted from approximately 100 mg of liver tissue using a high salt precipitation method (modified from Miller et al. 1988 and Sambrook et al. 1989; Gentra Systems, Minneapolis, MN) which preferentially precipitates proteins and cellular components from nucleic acids. Liver tissue was placed in 900µl of cell lysis solution (10mM Tris, 100mM EDTA, 2% SDS) with 180 µg of Proteinase K and incubated overnight at 60°C. Samples were cooled to room temperature, 40µg of Rnase was added, and then incubated at 37°C for one hour. Following incubation, 300µl of a 7.5M ammonium acetate solution was added, the samples were vortexed for 20 s, and placed on ice for 30 min. Samples were centrifuged at 12,000 rpm for 3 min to pellet the proteins and cell debris. The supernatant was transferred to a new tube containing 900µl of isopropanol and was centrifuged at 12,000 rpm for one min to pellet the DNA. Pellets were washed with 70% ethanol to remove salts, dried, and then resuspended in 10mM Tris-HCl, pH 8.5.

The DNA stocks were diluted to a final concentration of 100ng/µl for use in PCR. A total of 10 microsatellites (Tables 2 and 3; Figure 1) were chosen based on size and resolution. The microsatellites were coamplified (multiplexed) in two separate PCR reactions with different annealing temperatures (52° and 60° C). The 52°C reaction (Chinook Panel C) contained three microsatellite primer pairs while the 60°C reaction contained seven primer pairs (Chinook Panel D). Reactions were conducted in a total volume of 10µl and contained 225ng of template DNA, 2.5mM magnesium chloride, 125µM each dNTP, and approximately 0.3µM of each primer. Cycling conditions were as follows: 96°C for 2 min followed by 30 cycles of 94°C for 30 s, 52°C (or 60°C, depending on the primer set used) for 15 s, and 72°C for 1 min. A final extension at 72°C for 30 min was conducted to reduce "stutter bands" produced by the addition of a terminal adenine by the *Taq* polymerase.

Following PCR, the reactions were diluted to a volume of 100µl, and 3µl of the 52°C reaction was pooled with 2µl of the 60°C reaction in a clean tube. The samples were then dried in a vacuum centrifuge set on medium heat for approximately five min. Once the samples were dry, 4µl of gel loading buffer (formamide and 50mM EDTA; 5:1) and 0.5µl of internal lane standard (GS350-TAMRA; Applied Biosystems #401736) were added to each sample. The samples were heated to 90°C for two min, and then quenched immediately on ice. The samples were then loaded on a 6% (8.3M urea) polyacrylamide gel on an ABI 373A automated DNA sequencer. Samples were run for 9 h and then analyzed using the GeneScan Software (ABI Applied Biosystems 1995).

All ten loci could be successfully resolved in a single lane. This multiplex allows for up to 72 individuals/day or 720 genotypes/day to be analyzed on the automated DNA sequencer.

Panels were labeled as "C "and "D" to differentiate them from the chinook salmon panels "A" and "B" developed by Olsen et al. (in press) also using an automated approach on an ABI 373 A. The two sets of panels were developed independently, but overlap with the inclusion of *Ots1*, *Ssa85* and *Oneμ4*. Interestingly, Olsen et al. (in press) report poor resolution for several loci included in our panel (*Oneμ2, Oneμ10)*. This suggests that standardization efforts and laboratory collaborations will be necessary if a coastwide database, similar to that developed for allozymes, is to be constructed.

Future Directions

We have begun the population screening for the ten microsatellite loci for the 13 populations identified in Table 1 utilizing a sample size of 50 individuals/population. We anticipate completion of the screening within the next few months. Upon completion, this will represent one of the largest and most comprehensive microsatellite datasets available for a Pacific salmonid. The dataset will be particularly useful in evaluating the level and distribution of variability revealed by microsatellite loci over a wide geographic area. These data can then be compared to the allozyme dataset collected on an identical set of individuals. We are also exploring utilizing microsatellites in mixed fishery situations, such as the Southeast Alaska troll fishery, where product quality cannot be impaired as would result from allozyme sampling.

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Table 1. Populations of chinook salmon to be examined for microsatellite variation.

Region/Population		Year of Collection	N	Age
NORTHWEST				
	Bristol Bay (Upper Nushagak River)	1994	50	Adult
	Bristol Bay (Togiak River)	1994	50	Adult
	Yukon River (Stoney River)	1992	50	Adult
CENTRAL				
	Susitna R. (Moose Creek-Deshka R.)	1995	50	Adult
	Kenai River	1993	50	Juveniles
	Kodiak Island (Ayakulik River)	1993	50	Adult
SOUTHEAST				
	Unuk River - Wild	1994	53	Juveniles
	Chickamin River	1995	50	Adults
	King Salmon River- Hatchery	1993	50	Adult
	King Salmon River- Wild	1993	14	Adult
	Chilkat River			
	Big Boulder Creek	1992	21	Adult
	Big Boulder Creek	1993	25	Adult
	Tahini River	1992	50	Adult

Table 2. Panel of microsatellite primers used in chinook salmon.

Primer	Primer Sequence (5'→ 3') **F** > Forward, **R** > Reverse	Allele		Core Sequence	Source Species	Citation
		Range	Sizes			
Oneμ2	**F**>GGTGCCAAGGTTCAGTTTATGTT **R**>CAGGAATTTACAGGACCCTGGTT	194-216	194 196 200 208 210 216	$[GA]_{11}$	*Oncorhynchus nerka*	Scribner et al. in press
Oneμ4	**F**>TAATTTACATATCAGGTTCTGCC **R**>TATGCTAGTCATGGCTCTTACAT	95-111	95 97 109 111	$[GA]_{23}$	*O. nerka*	Scribner et al. in press
Oneμ5	**F**>AACACACCAGCTGTGAAAACAAA **R**>TGTCTATCGCCAATCTCTCTGCT	183-185	183 185	$[CA]_{12}$	*O. nerka*	Scribner et al. in press
Oneμ7	**F**>ACACTGCAAACACTCTGCTTACT **R**>CAAGAAGAAACCCTGTCCTCAAG	191-193	191 193	$[GA]_{11}N_2[GA]_4$	*O. nerka*	Scribner et al. in press
Oneμ9	**F**>CTCTCTTTGGCTCGGGGAATGTT **R**>GCATGTTCTGACAGCCTACAGCT	165-169	165 169	$[CA]_{54}$	*O. nerka*	Scribner et al. in press
Oneμ10	**F**>ATGGGGAACAGAAGAGGAAT **R**>CTGTAGGTGTGAAATGTATTTAAA	135-143	135 137 141 143	$[CA]_{25}$	*O. nerka*	Scribner et al. in press

Table 2. Continued.

Primer	Primer Sequence (5'→ 3') **F** > Forward, **R** > Reverse	Allele		Core Sequence	Source Species	Citation
		Range	Sizes			
Ots1	**F**>GGAAAGAGCAGATGTTGTT **R**>TGAAGCAGCAGATAAAGCA	183-185	183 185	$[TG]_3N_8[TG]_3N_{4..}$ $[TG]_3N_2[TG]_7N_{16..}$ $[TG]_9N_{15}\{TG]_2$	*O. tshawytscha*	Hedgecock et al. in press
Ots2	**F**>ACACCTCACACTTAGA **R**>AATATCCTTCACACTG	69-87	69 73 85 87	$[AC]_{17}$	*O. tshawytscha*	Hedgecock et al. in press
Ssa85	**F**>AGGTGGGTCCTCCAAGCTAC **R**>ACCCGCTCCTCACTTAATC	116-164	116 118 122 124 126 160 164	$[GT]_{14}$	*Salmo salar*	O'Reilly et al. 1996
µSat73	**F**>CCTGGAGATCCTCCAGCAGGA **R**>CTATTCTGCTTGTAACTAGACCTA	139-152	139 141 143 149 151	$[GT]_{12}TTATCT..$ $[CT]_3$	*Salmo trutta*	Estoup et al. 1993

Table 3. Multiplex analysis for chinook salmon. Fluorescent label assignments[1], PCR annealing temperature, and primer concentration for each multiplex set are given.

Multiplex Set	Anneal Temperature (°C)	Microsatellite Loci and Primer Concentration (μM)		
		6FAM (blue)	HEX (yellow)	TET (green)
Chinook Panel C	52		*Ots1*(0.25) *Ots2*(0.25)	*Oneμ7*(0.25)
Chinook Panel D	60	*Oneμ2*(0.25) *Oneμ4*(0.25) *Oneμ5*(0.25) *μSat73*(0.14)	*Oneμ9*(0.25) *Ssa85*(0.20)	*Oneμ10*(0.25)

[1] 6FAM=6-carboxyfluorescein, HEX=hexachloro-6-carboxyfluorescein, TET=tetrachloro-6-carboxyfluorescein. The fluorescent labels are visualized using the ABI filter set B.

Microsatellite Multiplex Panels for Chinook Salmon

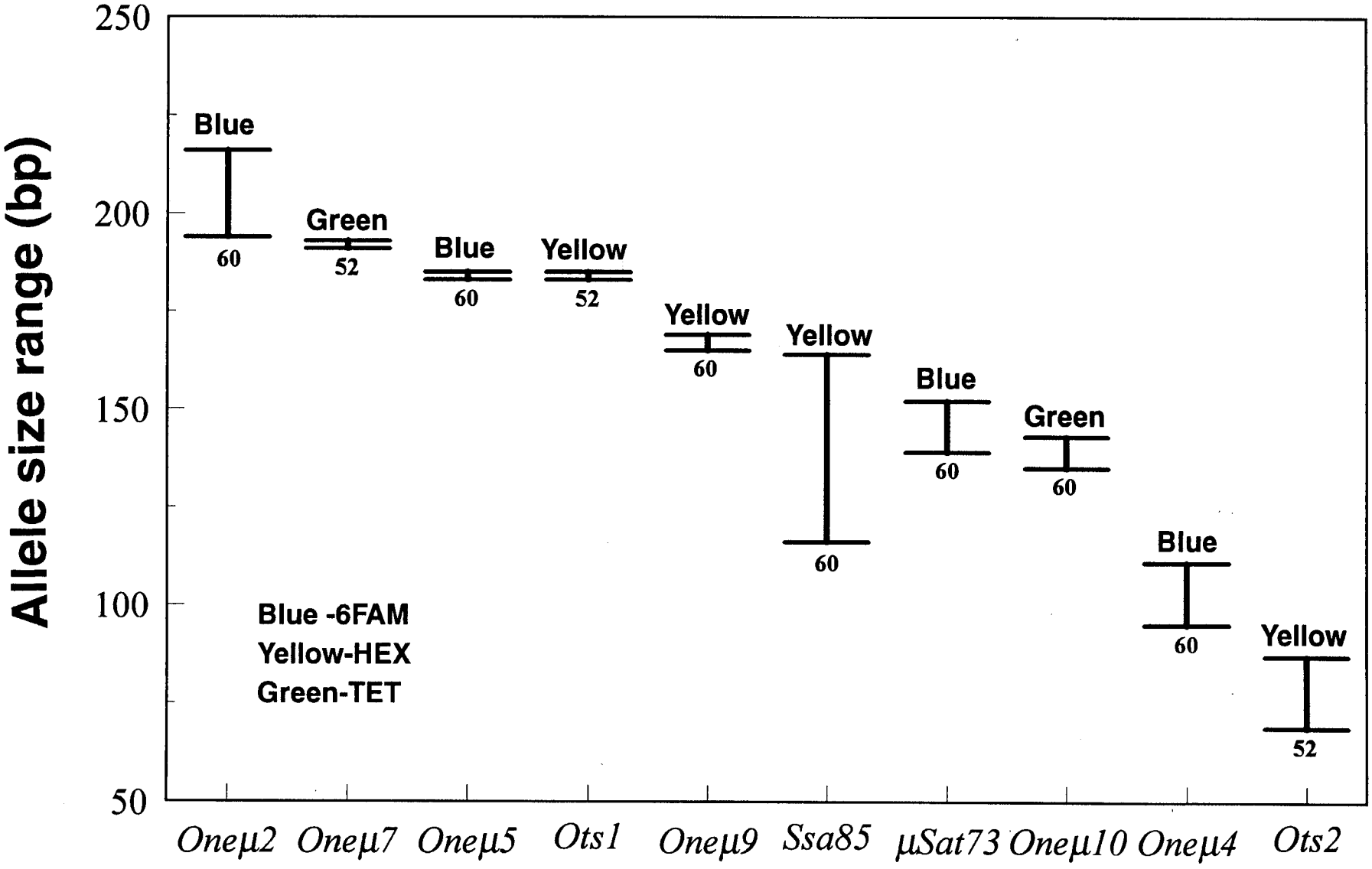

Figure 1. Microsatellite loci and allele size ranges in base pairs (bp) for chinook salmon. Dye color and amplification temperatures are given for each locus. Panel "C" is amplified at 52 degrees; Panel "D" is amplified at 60 degrees.

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